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KENYA
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Vol. XV—No. 1

JULY
1949

IN THIS ISSUE:

TREATMENT AND DISPOSAL OF WASTE
WATERS FROM DECORTICATION OF
SISAL

PROSPECTS FOR THE UTILIZATION OF
SISAL WASTE

THE USE OF BENZENE HEXACHLORIDE
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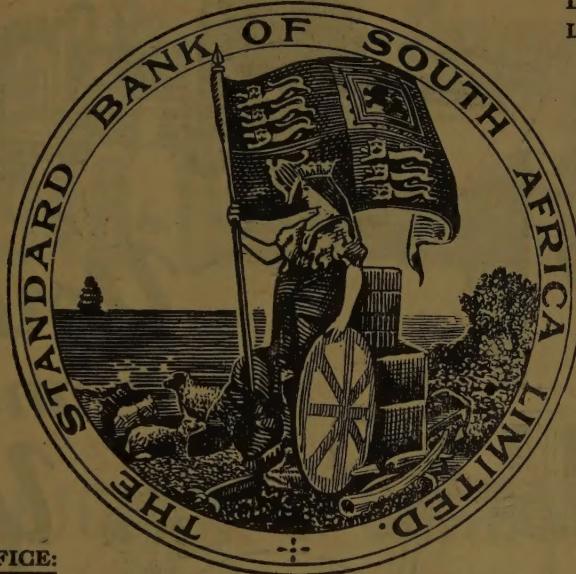
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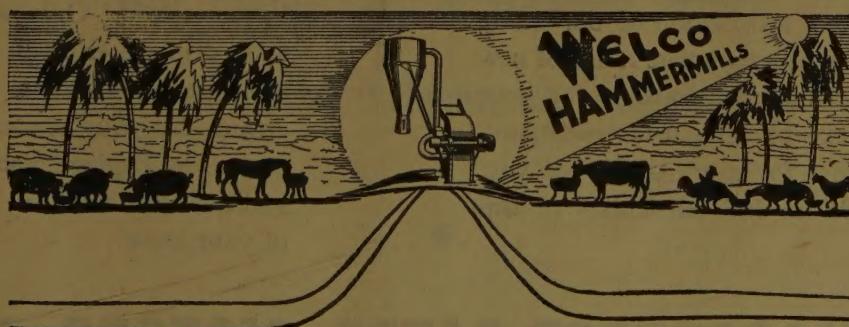


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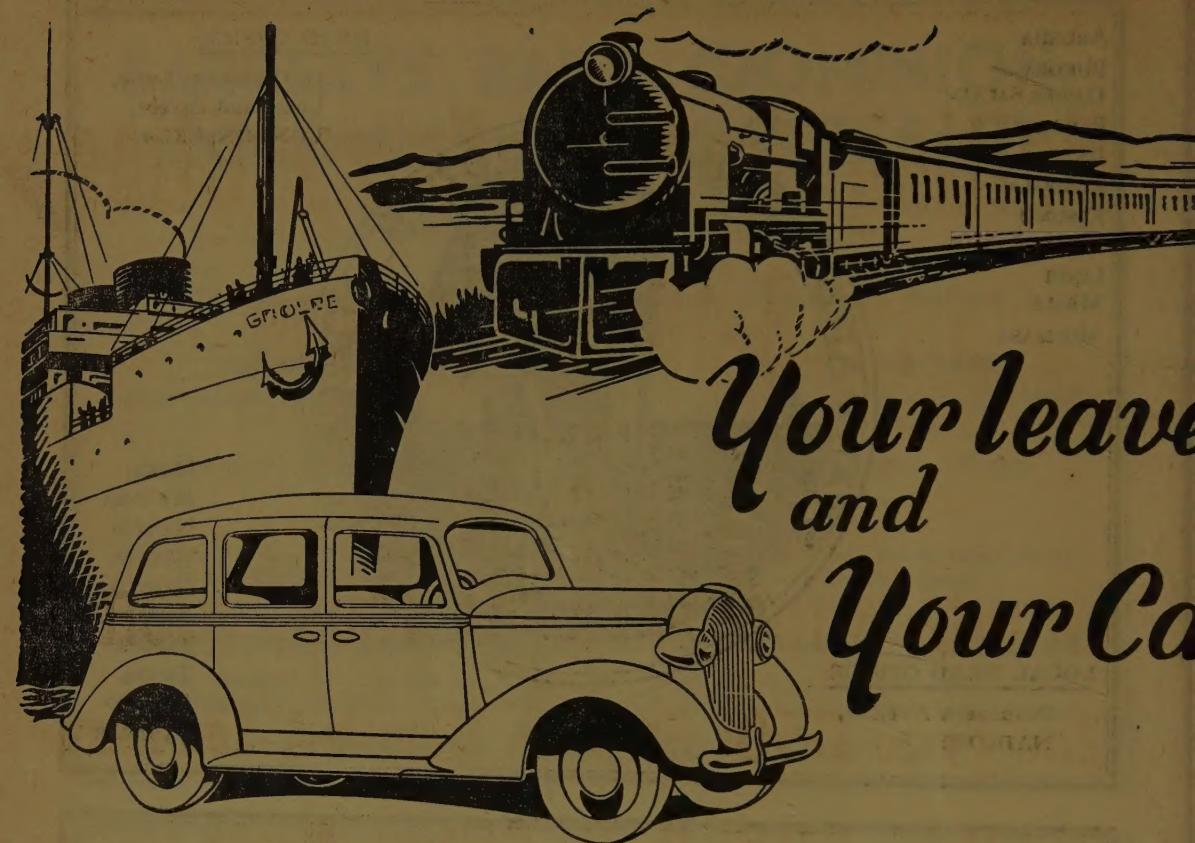
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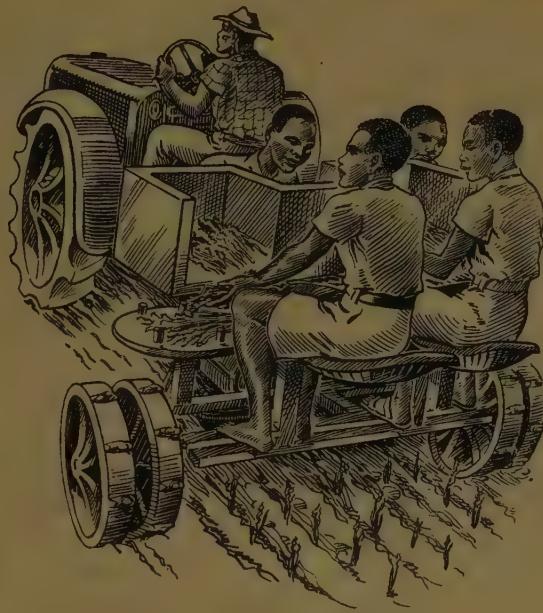
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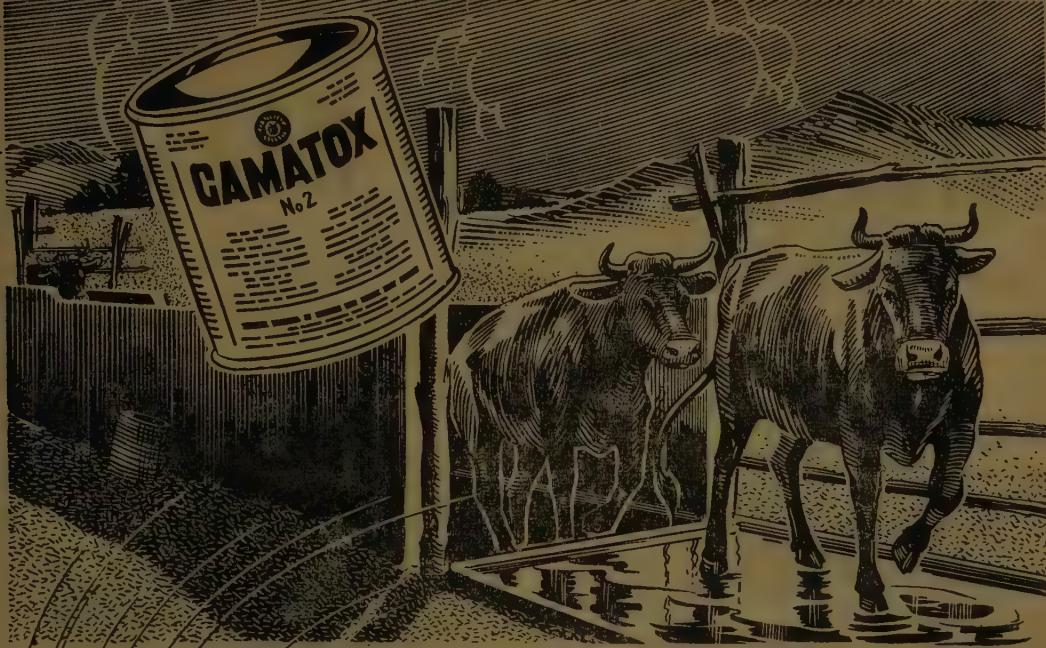
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JULY, 1949

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the *Journal* or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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SISAL WASTE

In this number we publish three articles of interest to the sisal industry. T. W. Brandon describes investigations on the treatment of effluent from the sisal factory to prevent pollution of streams; J. E. A. den Doop describes the methods of utilizing sisal waste; and W. Politzer shows how a more efficient recovery of flume tow can be obtained, and describes the extraction of by-products from the factory waste.

Den Doop's article draws on his long experience of sisal production in Java and couples this with his present observations in the New York markets. He holds out the warning that the East African sisal industry will soon feel the effects of keen competition from Indonesia, and he stresses the urgency of meeting this challenge with more efficient use of the soil and with the manufacture of by-products which will cheapen the cost of production per ton of fibre.

In a highly organized industry such as that of sisal production there is a danger that efficiency may be considered to be a matter of getting the best work out of the labour force and cutting expenses to a minimum by strict cost accounting. Both these factors are important in a plantation crop which covers large acreages and employs very large numbers of labourers, but den Doop takes a wider view of efficiency when he points out that under the present East African methods of production 95 per cent of the harvested leaf is thrown away. This sisal waste contains plant residues which could improve the moisture-retaining capacity of the soil; it contains much-needed chemical plant foods which have been removed by the sisal plant; it also contains economic by-products, such as pectin, detergents and sisal wax, which could be extracted to give a higher financial return per acre and so reduce the cost of production of marketable fibre.

If we look on the sisal leaf as a chemical factory which uses as its raw material the sun's energy, the rain, and the chemical components of the soil, it is striking how efficiently these raw materials are converted into a variety of chemical compounds. But 95 per cent of the product thus manufactured is thrown away in preparing it for the market. If we compare this with the wastage in a

synthetic fibre factory, for example a nylon factory, it is clear that a wastage of this magnitude would kill the industry. In the synthetic chemical factory wastage is reduced to the absolute minimum, and every possible by-product is extracted from the waste material left by the main product. It is noticeable that when a new synthetic product starts to compete with a natural substance the cost of production is usually prohibitive, but after a time the cost of production drops rapidly and may fall far below the cost of the natural product. Much of this drop in production cost may result from the manufacture of by-products, in other words from the reduction of waste. The substitution of synthetic indigo for the natural product was a striking example of the utilization of by-products, since the synthetic product was produced from a by-product of the coal gas industry, and thus the cost of raw material was very low, and the synthetic product was very quickly able to compete in the open market with the natural substance.

The three articles referred to above view the problem of sisal waste from different angles, but with the same objective of increased efficiency of production. Brandon deals with the treatment and disposal of sisal waste, primarily for the prevention of stream pollution but also with a view to the better use of available water. In sisal-growing areas where the water supply is limited it would be a great advantage if the waste water could be purified and reused. Thus, although efficiency in production is of secondary importance in Brandon's work, it does find a place. In den Doop's article efficiency of production is the main theme; the production of more sisal in the field by manuring with sisal waste, and the lowering of production costs by the extraction of by-products from the waste before it is returned to the fields.

Both den Doop and Brandon suggest that the sisal industry in East Africa should investigate the possibilities of dry decortication followed by washing the resulting fibre with water. Den Doop has worked out a method of combining the two processes in one decorticator, but he points out that research would be required before a pure white fibre could be assured by this process. Brandon tested dry decortication from the point of view of stream pollution and found that the pol-

luting character of the waste waters could be reduced by nearly 90 per cent by adopting dry decortication and washing the fibre alone. He suggests that flume tow recovery would be much more economically carried out if the solid waste were discharged from the decorticator in a substantially dry condition. The advantages claimed for dry decortication by den Doop are that the dry waste from this can be used for the extraction of pectins, detergents, and sisal wax without the expensive drying process which would be necessary with wet decortication waste, and the final waste product would be sufficiently dry to be returned to the fields in the trucks which bring the fresh leaf. But he points out that in order to obtain the best fibre from dry decortication it may be necessary to extract the crude fibre with a solvent such as alcohol, the final finishing being carried out by another chemical such as oxalic acid. While simpler methods such as double decortication by den Doop's dry/wet method, or by retting, would be satisfactory up to a point, he believes that ultimately the sisal factory should become a small chemical plant, run by chemical engineers, in which the waste from the decortication process is relieved of all its economic by-products before it is returned to the soil. Politzer gives an outline of the by-product processes in his article, and they are relatively simple although they require considerable capital expenditure and strict technical control.

This does not mean that the exhausted waste will be reduced in value as a fertilizer, since the extracted substances are of no value in plant nutrition, and the chemical plant-foods, such as lime, phosphate and potash, will not be removed in the process. There will still be sufficient organic plant residues to maintain or improve the moisture-retaining capacity of the soil, and the residues from the chemical plant would be dry and relatively easy to apply as manure. In this way all the

harvested sisal would be utilized, and by returning the waste to the soil the expenditure in fertilizers would be greatly reduced and the effects of irregularities in rainfall would be reduced to some extent.

Another suggestion put forward by den Doop merits careful consideration. He points out the difficulty of obtaining a white fibre by dry decortication, and gives several methods which might be tried in the finishing process. One of these methods is that of retting with continuous changing of the water, but the resulting fibre is "unusually soft on account of the protracted contact with water". Den Doop goes on to say that "fibre softness may be appreciated for specified purposes by some buyers of sisal fibre". This suggests that different kinds of finished fibre might be manufactured, each for a specific industrial purpose. Research on this branch of the subject is now being carried out in England, in co-operation with the sisal growers of East Africa, and the results of this work may possibly produce marked changes in the sisal industry.

Plantation agriculture in the tropics has been handicapped in the past by the narrow objective of marketing the same product decade after decade irrespective of the changes in world economics. Slumps and booms have obscured the fact that there has been a downward trend in the relative value of tropical crop products, and costs of production have risen in direct proportion to the price of labour without the ameliorating effects of increased efficiency. Manufacturers in the United Kingdom have offset the increases in labour costs by increasing the productive capacity of the worker, and if the sisal industry were to make the best possible use of every ounce of leaf removed from the field it might weather future economic storms without undue strain.

D.W.D

TREATMENT AND DISPOSAL OF WASTE WATERS FROM DECORTICATION OF SISAL

By T. W. Brandon, Water Pollution Research Laboratory, Watford, England

(Received for publication on 23rd May, 1949)

During recent years, concern has been felt in East Africa over problems of water pollution, particularly from processing of coffee (Brandon, 1948) and of sisal. At many sisal factories the whole of the liquid and solid waste is discharged to rivers without treatment (Fig. 1); even where liquid waste alone is discharged, serious pollution frequently results. At the invitation of the Government of Kenya, the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research of Great Britain has investigated means of reducing this pollution.

VOLUME AND COMPOSITION OF THE WASTE WATERS

The waste waters are produced during separation of fibre from the fleshy part of the leaves by decortication. Water is passed through the decorticator to wash the fibre and to carry away the tow and leaf debris, which are then discharged through a flume, at the head of which additional water is usually added to assist in removing the waste material.

Results of examination of the waste waters, after screening through wire mesh with approximately 16 meshes to the inch, are shown in Table I.

The waste waters were acidic; as judged by the test for oxygen absorbed from acid N/80 potassium permanganate, they were generally about 20 to 30 times as polluting in character as average domestic sewage, and as judged by the test for biochemical oxygen demand (B.O.D.)*, they were generally between four and six times as polluting as sewage.

At the factory where these determinations were made, about 80 tons of leaves were processed during a working period of about ten hours and about 11,000 gallons of waste waters were discharged per hour. Hence, when judged by the test for B.O.D., the liquid wastes discharged during processing of 100 tons of leaves would be equivalent in polluting character to between 550,000 and 825,000 gallons of crude domestic sewage, that is, to the sewage from a population of between 22,000 and 33,000. At many factories at least 300 tons of leaves may be processed in a day.

TREATMENT OF THE WASTE WATERS

Treatment by Sedimentation or Mechanical Filtration.—Laboratory experiments (Table II) indicated that the polluting character of the waste waters, previously screened through wire gauze, could be only slightly reduced by sedimentation or mechanical filtration.

Treatment With Coagulants.—Small-scale experiments were made on the effect on the waste waters of the more commonly used chemical coagulants, including calcium hydroxide, ferric chloride, ferric sulphate, ferrous sulphate, and aluminium sulphate, and mixtures of calcium hydroxide with each of the other substances. The results varied considerably with different coagulants and with different samples of waste water treated with the same coagulant; a summary of the results is given in Table III.

In general, there were only slight reductions in the values for oxygen absorbed from acid permanganate, and no consistently large reductions in the values for B.O.D. Even under the most satisfactory conditions, where the polluting character was reduced by about 50 per cent, the liquid remaining after treatment would still be too polluting for discharge to a small stream. It was concluded that addition of coagulants would not be a suitable method of treatment.

Treatment by Fermentation.—Some experiments were made in the laboratory to ascertain whether the polluting character of the waste waters could be reduced by allowing the liquid to undergo fermentation under natural conditions. Waste waters were allowed to stand at room temperature (15° to 20°C.) in open dishes for 12 days and samples were taken at intervals for examination. Results obtained during two series of experiments are shown in Table IV. The pH value fell, and the titratable acidity increased, during the first day of fermentation. Subsequently, the pH gradually increased, reaching a value of about 8 after 12 days. The values for oxygen absorbed from acid permanganate fell steadily during the course of each series of experiments. On the other hand, the values for B.O.D. exhibited several

* The biochemical oxygen demand (B.O.D.) test is a method which gives an estimate of the quantity of oxygen which would be absorbed by a liquid when discharged to a river. The average B.O.D. of crude domestic sewage is about 40 parts per 100,000 if the volume is 25 gallons per person per day.

fluctuations, but in each series were ultimately little changed from the original, even after fermentation for 12 days. It appears that this method of treatment would not be of great value in reducing the polluting character of the waste waters.

Treatment by the Activated-Sludge Process.—Laboratory experiments were made on treatment by the activated-sludge process, employing brush aeration in shallow dishes and using an activated sludge built up by aerating sewage and humus sludge from the Nairobi sewage disposal works. With sewage containing five per cent (by volume) raspador effluent fairly satisfactory results were obtained with periods of aeration of three to four hours (Table V). A series of experiments made with progressive reductions in the proportion of sewage in a mixture of sewage, raspador effluent and activated sludge effluent gave satisfactory results when the concentration of settled sewage was not less than two per cent by volume of the mixture (Table VI). With a lower concentration of sewage the results were unsatisfactory.

Treatment by Aeration.—Results of examination of samples taken during laboratory experiments in which waste waters were vigorously agitated by blowing in bubbles of air through a sintered glass plate are shown in Table VII. Aeration alone, in the absence of activated sludge caused little reduction in the polluting character of the liquid.

Treatment by Biological Filtration, With Re-use of Effluent.—As the limited supply of water is frequently a serious problem on East African estates, it was decided to devote the main part of the investigation to examination of a method by which the waste waters could be treated and re-used in the process. Since there would be no discharge of liquid from the system, the question of pollution of a river would not arise, and the waste waters would be given only sufficient treatment to render them suitable for re-use in the process.

A large experimental plant, in which waste waters from a raspador could be treated by biological filtration* and re-used, was constructed and brought into use in March, 1947 (Figs. 2 and 3). In this plant waste waters were screened, first through a bar screen with $\frac{1}{4}$ -in. openings and then through fine wire-mesh

screens and mixed in a constant-level tank, with effluent from the filter and with enough river water to compensate for water lost with the wet pulp and fibre. The diluted waste water then flowed to a well from which it was pumped to the rotating distributor of a circular percolating filter, 17 ft. in diameter and approximately 7 ft. 6 in. deep, containing 50 cubic yards of stone (local blacktrap), graded $1\frac{1}{2}$ to 2 in. The filter effluent drained to a peripheral channel from which it flowed to a humus tank. After sedimentation in the humus tank some of the water flowed to the raspador and the remainder to the constant-level tank.

To establish an active film of micro-organisms on the filtering medium, river water was first re-circulated continuously through the filter for about a fortnight. Small quantities of sisal effluent were then introduced into the system, at first from the factory and subsequently from the raspador. The weight of leaves decorticated in the raspador was then increased by stages in order to determine the maximum weight of leaves from which the waste waters could be treated satisfactorily in a filter of given size.

A summary of the main results for each weight of leaves processed per day is shown in Table VIII. Effluent from the raspador was smaller in volume but more polluting in character than effluent from the factory decorticator. The biochemical oxygen demand of the filter effluent rarely exceeded five parts per 100,000 in the morning when the raspador started operating but it increased considerably during the day. Effluent returned from the filter to the raspador was generally slightly alkaline in reaction and, except during the period 13th October to 9th November, when the filter was receiving its maximum loading and the river water was exceptionally clear in the absence of rain, filter effluents were generally only slightly more coloured than the river water used as factory supply (Table IX). Re-use of filter effluent for further decortication would be unlikely to have any adverse effect on the quality of the fibre.

During the last period of operation the average rate of application of mixed liquid to the filter was 390 g.p.h., equivalent to about 190 gallons per cubic yard of filtering medium per day; all the liquid in the system was passed

* In biological filtration, the liquid is passed through a bed of broken stone or other suitable hard material, on which a film of bacteria, fungi, and other organisms has been established. Purification of the liquid takes place during contact with the film, which is readily established by circulating river water through the filter for two to three weeks, and then introducing sisal effluent in gradually increasing quantities until the designed loading is reached.

TREATMENT AND DISPOSAL OF WASTE WATERS FROM DECORTICATION OF SISAL



FIG. 1—East African river polluted by sisal wastes.



FIG. 2—Experimental plant for treatment of waste waters by biological filtration.

TREATMENT AND DISPOSAL OF WASTE WATERS FROM
DECORTICATION OF SISAL

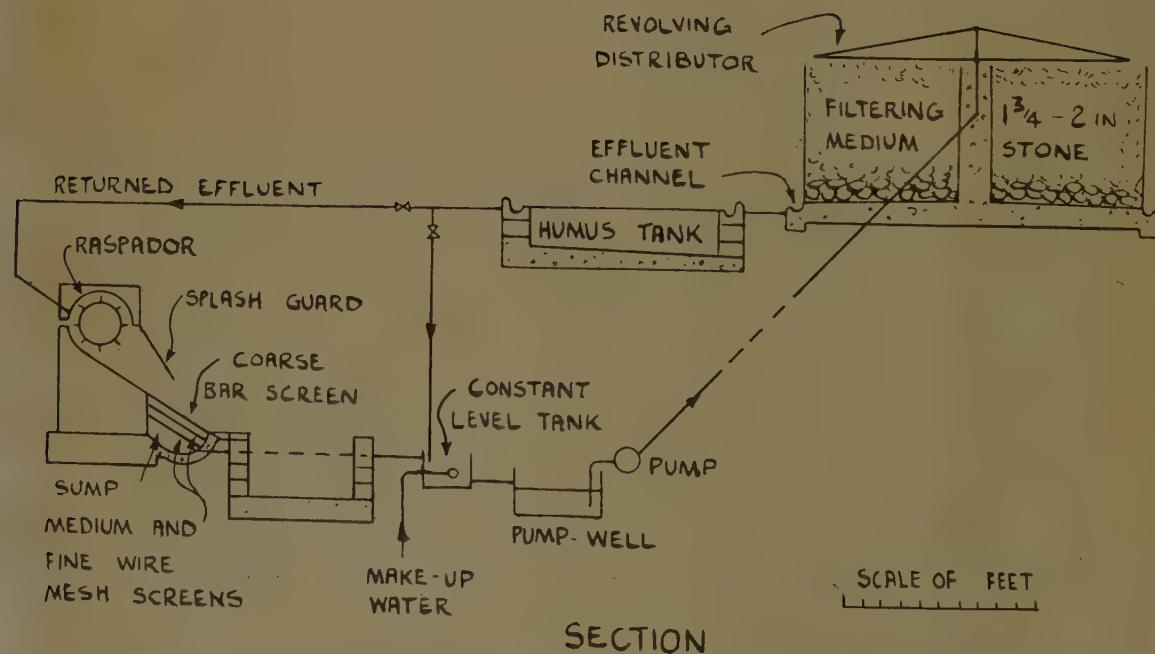
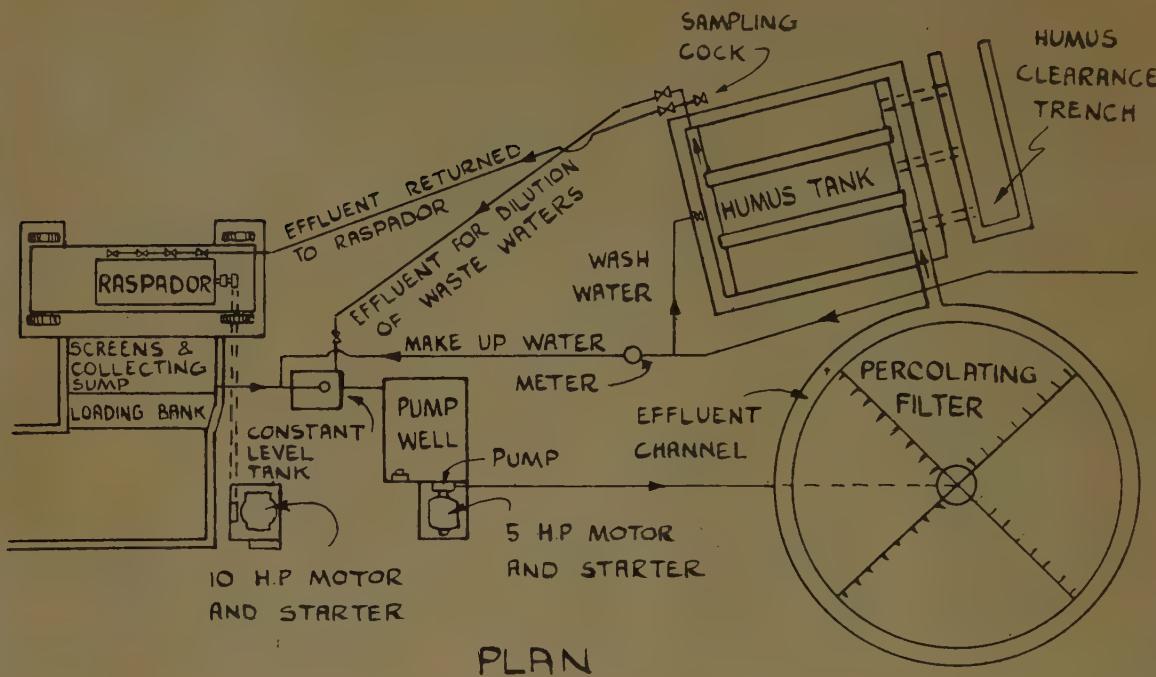


FIG. 3—Layout of experimental plant for treatment of waste waters by biological filtration.

through the filter nearly seven times during each period of 24 hours. The average volume of make-up water required during the period 13th October to 9th November, 1947, was 104 gallons per day, equivalent to about 16 per cent of the total volume of water used in the raspador. Re-use of filter effluent for further decortication thus afforded a saving in water consumption of over 80 per cent. Waste waters from the raspador during this period were equivalent in total polluting character to waste waters from the decorticator for an equivalent weight of leaves. Hence, for a factory processing 100 tons of leaves daily, a treatment plant containing 4,000 cubic yards of filtering medium would be required; a suitable single filter would be about 150 ft. diameter and 6 ft. deep. From figures supplied by the Hydraulic Engineer, Public Works Department, Nairobi, the present capital cost, in the Nairobi district, of a complete installation (excluding screens and allowing for contractor's profit) would be about £8,000. The cost could probably be reduced to some extent by employing direct labour, particularly if a suitable hard stone for use as filtering medium were available near the site. The medium in biological filters will normally last for a long period without deterioration (Brandon, 1948).

In districts where water is scarce, re-use of filter effluent for further decortication would ensure that the available supplies were kept clean and would thus permit increased production of washed fibre.

Treatment by Biological Filtration, Without Re-use of Effluent.—Where water supplies are ample and fresh water can be used for decortication it might still be necessary to treat the waste waters before returning them to a river.

Some further experiments were made with the biological filter described in the previous section. Waste waters were screened through wire gauze with approximately 16 meshes to the inch, and were diluted with treated effluent from the filter in a small mixing tank; the mixed liquid was applied to the filter at a rate of 60 gallons per cubic yard of filtering medium per day.

Results of these experiments (Table X) indicated that when waste waters previously diluted with four times their own volume of filter effluent were applied to the filter, effluents of fair quality were obtained. When the proportion of waste waters was increased to 25 per cent of the volume of mixed liquid applied to the filter, much less satisfactory results were

obtained, particularly after 26th June, when the waste waters were more polluting in character.

The filter required to treat by this method the waste waters from a factory processing 100 tons of sisal leaves per day would contain about 11,000 cubic yards of filtering medium if the waste waters were diluted with four times their own volume of filter effluent before treatment. This is considerably larger than the filter required when effluent is continuously re-circulated through the filter at a high rate, with no discharge of liquid from the system, as described in the previous section.

It seems preferable, therefore, even where an ample supply of fresh water is available, to treat the waste waters at a high rate with re-circulation of effluent, so that the mixed liquid is passed through the filter several times before discharge from the system.

SUGGESTED MODIFICATIONS OF FACTORY PROCEDURE

It appears from the experimental work that the most satisfactory means of treatment of the waste waters would be by biological filtration, but the cost of this method, although not prohibitive, is high. It is therefore necessary to consider whether the polluting character of the waste waters can be reduced by modifications in factory procedure.

In the present method of wet decortication, the whole leaf is broken up and brought into contact with water. This method is wasteful of water, since only the final product, the fibre, requires washing, and it produces waste waters which are unnecessarily polluting, since soluble acids, sugars and other substances are leached from the whole leaf instead of from the fibre only.

Some experiments were made to determine the reduction in polluting character obtained by washing the fibre alone after separation by dry decortication. For comparison, the ratio of volume of water to weight of sisal used in these experiments was the same as that used in the factory decorticator, including water added at the head of the flume. Weighed samples of sisal leaves were decorticated in a raspador without water, the fibre was immediately stirred with water for periods of 10, 20 and 30 minutes, and samples of the liquid were withdrawn for examination. It is realized that fibre would not be stirred with water at a factory owing to the necessity for keeping the fibres as straight as possible, but stirring was used in these experiments in order to ascertain the maximum strength of liquid which could be

expected from washing fibre alone. For comparison, composite samples of effluent from the factory decorticator were taken on each day on which these experiments were made.

The results (Table XI) indicate that the polluting character of the waste waters, as measured both by oxygen absorption and by B.O.D., could be reduced by nearly 90 per cent by adopting dry decortication and washing the fibre alone. The cost of treatment of the waste waters would be correspondingly decreased. It is obvious, too, that a fairly short period of washing would be required, since the waste waters produced after washing for 30 minutes were no more polluting than those produced by washing for only 10 minutes. Probably the best means of washing would be by sprays as the fibre is leaving the decorticator. Moreover, it should be possible to use a smaller volume of water than that used during wet decortication and fluming.

The suggested modification in procedure involves a radical change in the present method of decortication, but in addition to reducing the polluting character of the waste waters it would greatly facilitate subsequent extraction of tow and by-products from the solid waste.

In the present methods of flume tow recovery, the solid waste is usually separated from fluming water by screening, and is then passed through rollers to remove as much water as possible before the tow is separated by "teasing". It is obvious that tow could be much more economically separated if the solid waste were discharged from the decorticator in a substantially dry condition.

According to a recent report (Anon, 1948), it has been found experimentally that almost all the waste solid material can be converted by processes which are now to be tested on a scale suitable for commercial application into products of commercial value. A full-scale extraction plant has been built, and it is stated that further plants will be built in Kenya and Tanganyika. Among the products obtained from the solid waste on an experimental scale were wax with a high melting point, pectins and pectates, hydroxy acids, saponins, glucosides and fermentable sugars, and aliphatic acids, vanillin and phenols. Extraction of by-products would be considerably easier if the solid leafy material were separated from the fibre by dry decortication instead of by the method now used. It would also be much easier to dispose of surplus

waste material, for example, by burning if it were dry, and the serious seasonal pollution which frequently results when rain water flows into streams after percolating through accumulations of rotting vegetable debris produced by the present means of disposal would be avoided.

It has been shown that the effluent necessarily discharged, that is, from washing of fibre only, would be only about 10 per cent as polluting in character as the effluent at present discharged from factories using wet decortication. There is little doubt that this less polluting effluent could be satisfactorily treated by biological filtration at a high rate with continuous re-circulation of effluent to yield a final effluent of good quality. The biological filter required at a factory processing 100 tons of leaves daily would contain about 400 cubic yards of filtering medium; the present capital cost of the installation, calculated on the same basis as before, would be about £1,200.

SUMMARY

1. Waste waters discharged from sisal factories are acidic, with a pH value about 5, and are strongly polluting.
2. Laboratory experiments indicated that the polluting character of the waste waters, previously screened through wire gauze, could not be greatly reduced by sedimentation or mechanical filtration.
3. By treatment of the waste waters with coagulants, the greatest reduction achieved in polluting character was about 50 per cent, but the liquid remaining after treatment would still be too polluting for discharge to small rivers.
4. Laboratory experiments on treatment by natural fermentation indicated that this method would not be of great value in reducing the polluting character of the waste waters, as measured by the test for biochemical oxygen demand.
5. Laboratory experiments with the activated-sludge process showed that satisfactory purification could be obtained by treating diluted sisal effluent containing not less than two per cent sewage by volume. With a lower concentration of sewage the results were unsatisfactory.
6. Aeration alone, in the absence of activated sludge, caused little reduction in the polluting character of the waste waters.
7. Large-scale experiments showed that the waste waters could readily be treated by biological filtration, with re-use of effluent for

further decortication. By this method of operation, in which the liquid was continuously re-circulated through the system at a high rate, water consumption could be reduced by over 80 per cent, and no waste waters need be discharged. The capital cost of the installation required at a factory processing 100 tons of leaves daily would be about £8,000.

8. Large-scale experiments in which waste waters, previously diluted with filter effluent, were treated by single biological filtration at a rate of 60 g.y.d. indicated that this method of operation was much less efficient than the method in which the liquid was continuously re-circulated through the filter at a high rate with no discharge of liquid from the system.

9. By adopting a process of dry decortication, with subsequent washing of fibre, the polluting character and the cost of treatment of the waste waters could be reduced by nearly 90 per cent. Recovery of flume tow and extraction of valuable by-products from sisal flesh would be greatly facilitated by dry decortication.

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TABLE I
RESULTS OF EXAMINATION OF WASTE WATERS FROM DECORTICATION OF SISAL IN KENYA

	Aug. 28th to Sept. 30th 1946	Feb. 19th to Mar. 31st 1947	May 15th to June 27th 1947	July 7th to Nov. 14th 1947
pH value—				
Highest	5.2	5.6	5.2	5.7
Lowest	4.5	4.7	4.9	4.4
Titratable acidity (ml. 0.1N NaOH for 100 ml. of sample)—				
Highest	11.6	10.6	13.0	8.2
Lowest	2.7	1.8	3.6	2.5
Mean	5.9	4.8	7.5	5.5
Parts per 100,000				
Oxygen absorbed from N/80 KMnO ₄ in 4 hrs. at 26.7°C.—				
Highest	437	416	412	394
Lowest	182	125	190	137
Mean	269	272	301	231
Biochemical oxygen demand in 3 days at 26.7°C.—				
Highest	485	280	305	260
Lowest	70	61	70	70
Mean	224	147	175	136
Total solids—				
Highest	925	1,030	972	806
Lowest	366	275	393	291
Mean	567	616	668	468
Volatile solids—				
Highest	795	924	831	731
Lowest	313	241	347	244
Mean	490	546	595	404
Suspended solids—				
Highest	70	66	62	53
Lowest	31	21	36	15
Mean	48	44	51	31

TABLE II
RESULTS OF TREATMENT OF WASTE WATERS BY SEDIMENTATION OR MECHANICAL FILTRATION

Method of treatment	Duration of treatment (hours)	Oxygen absorbed from acid N/80 KMnO ₄ in 4 hrs. at 26.7°C.	Biochemical oxygen demand in 3 days at 26.7°C.
		Parts per 100,000	
None (original sample) ..	—	211	168
Sedimentation ..	0.5	208	172
	1	212	148
	2	203	193
	4	201	198
Filtration through No. 40 Whatman filter paper..	—	182	147

TABLE III
SUMMARY OF RESULTS OF ADDITION OF COAGULANTS TO WASTE WATERS

Coagulant	Concentration of coagulant (parts anhydrous compound per 1,000000)	Volume of settled sludge (per cent)	Range of pH value of treated liquid	Reduction in polluting character (per cent) (— = reduction; + = increase)	
				Based on oxygen absorbed from acid N/80 KMnO ₄ in 4 hrs. at 26.7°C.	Based on biochemical oxygen demand in 3 days at 26.7°C.
Calcium hydroxide ..	40 to 100	1 to 7	10.0 to 12.2	—2 to +12	+3 to +56
Ferric chloride ..	40 to 100	1 to 3	4.2 to 2.4	—1 to +18	—1 to +54
Ferric sulphate ..	40 to 80	1	4.5 to 4.0	+1 to +2	+16 to +43
Ferrous sulphate ..	20 to 80	0.5 to 1	4.7 to 3.8	+2 to +5	+19 to +29
Aluminium sulphate ..	60	2	3.5	—1	—28
	100	2	3.3	+1	+30
Calcium hydroxide and ferric sulphate ..	Ca(OH) ₂ 80 Fe ₂ (SO ₄) ₃ 20-80	1.5 to 2.5	6.6 to 6.1	—1 to +4	—4 to +17
Calcium hydroxide and ferric chloride ..	Ca(OH) ₂ 100 FeCl ₃ 20 to 80	5 to 7	11.6 to 10.0	+9 to +15	+20 to +41
Calcium hydroxide and ferrous sulphate ..	Ca(OH) ₂ 80 FeSO ₄ 20 to 80	2 to 2.5	8.0 to 6.3	—1 to +2	—4 to +11
Calcium hydroxide and aluminium sulphate ..	Ca(OH) ₂ 60 Al ₂ (SO ₄) ₃ 20-80	2 to 3	10.2 to 8.1	Nil to +2	+15 to +21

TABLE IV
RESULTS OF TREATMENT OF WASTE WATERS BY NATURAL FERMENTATION

Period of fermentation (days)	pH value		Titratable acidity or alkalinity (ml. 0.1N for 100 ml. of sample — = acidity + = alkalinity)		Oxygen absorbed from acid N/80 KMnO ₄ in 4 hrs. at 26.7°C.		Biochemical oxygen demand in 3 days at 26.7°C.	
	1st series	2nd series	1st series	2nd series	1st series	2nd series	1st series	2nd series
0	5.2	5.3	—4.8	—4.2	229	228	128	106
1	3.9	4.3	—8.5	—8.7	189	188	152	113
2	6.0	4.6	—7.3	—7.4	168	163	139	97
3	6.6	5.1	—2.3	—2.7	128	141	138	97
5	6.5	6.7	—1.1	—0.4	130	128	138	112
7	7.3	7.2	+1.3	+0.6	117	107	195	144
12	8.2	8.0	+4.2	+3.3	97	90	106	131

TABLE V

AVERAGE RESULTS OF TREATMENT BY THE ACTIVATED-SLUDGE PROCESS OF SETTLED SEWAGE CONTAINING 5 PER CENT BY VOLUME, RASPADOR EFFLUENT

Period of aeration (hours)	Oxygen absorbed from N/80 acid KMnO ₄ in 4 hrs. at 26.7°C. (parts per 100,000)		Biochemical oxygen demand in 3 days at 26.7°C. (parts per 100,000)		Reduction in polluting character (per cent)	
	Settled sewage containing 5 per cent raspador effluent	Activated sludge effluent	Settled sewage containing 5 per cent raspador effluent	Activated sludge effluent	Based on O.A.	Based on B.O.D.
1st series	2	17	6.7	40	10	61
	3	33	5.0	33	6.2	85
	5	16	3.2	26	2.6	80
	8	23	4.2	49	4.1	82
	14	23	3.5	49	2.3	85
	20	16	2.9	37	0.4	82
2nd series	3	22	3.5	54	4.5	84
	4	22	3.1	54	4.4	86
	5	22	2.9	54	3.4	87
	6	22	2.9	54	3.0	87

TABLE VI

AVERAGE RESULTS OF TREATMENT BY THE ACTIVATED-SLUDGE PROCESS OF MIXTURES OF RASPADOR EFFLUENT, SETTLED SEWAGE, AND ACTIVATED SLUDGE EFFLUENT

Period of aeration approximately 22 hours

Period (1947)	Proportion in mixture (per cent)			Oxygen absorbed from acid N/80 KMnO ₄ in 4 hrs. at 26.7°C.		Biochemical oxygen demand in 3 days at 26.7°C.		Reduction in polluting character (per cent)	
	Raspador effluent	Settled sewage	Activated sludge effluent	Parts per 100,000				Based on O.A.	Based on B.O.D.
				Before treatment	After treatment	Before treatment	After treatment		
June 7-9	5	47.5	47.5	20	1.8	43	0.8	91	98
June 10-15	7	23.3	69.7	20	2.1	41	1.1	90	97
June 17-21	8	15	77	24	2.2	40	0.6	91	99
June 22-26	10	10	80	31	2.1	43	1.3	93	97
June 28-30	10	7	83	46	2.4	59	3.0	95	95
July 1-3	7	5	88	41	3.1	49	3.7	92	93
July 8-11	5	3	92	25	3.2	33	3.3	87	90
July 15-22	5	2	93	32	4.0	47	3.1	88	93
July 29 to Aug. 11	5	1	94	45	9.2	36	9.8	79	76

TABLE VII

AVERAGE RESULTS OF TREATMENT OF WASTE WATERS BY AERATION

Period of aeration (hours)	Oxygen absorbed from acid N/80 KMnO ₄ in 4 hrs. at 26.7°C.		Biochemical oxygen demand in 3 days at 26.7°C.	
	Parts per 100,000			
0	236		140	
1	230		140	
2	231		173	
4	223		185	
8	213		138	

TABLE VIII
AVERAGE RESULTS OF ANALYSIS OF WASTE WATERS FROM EXPERIMENTAL RASPADOR AND OF EFFLUENT AFTER TREATMENT ON A PERCOLATING FILTER

Period of experiment (1947)	July 1-20	July 21 to Aug. 24	Aug. 28 to Sept. 21	Sept. 22 to Oct. 12	Oct. 13 to Nov. 9
Weight of sisal leaves processed (cwt. per day)	10	12	16	20	25
Oxygen absorbed from N/80 KMnO ₄ in 4 hrs. at 26·7°C. (Parts per 100,000)					
Crude waste waters	516	566	482	472	447
Liquid applied to filter	94	116	110	73	85
Filter effluent (start of working day)	5	4	5	5	6
Filter effluent (end of working day)	23	22	29	28	23
Biochemical oxygen demand in 3 days at 26·7°C.					
Crude waste waters	341	303	278	317	418
Liquid applied to filter	66	62	68	51	80
Filter effluent (start of working day)	5	2	4	4	4
Filter effluent (end of working day)	14	12	17	25	38

TABLE IX
pH VALUE AND COLOUR OF FILTER EFFLUENTS AND OF FACTORY SUPPLY WATER

Period of experiment (1947)	July 1-20	July 21 to Aug. 24	Aug. 28 to Sept. 21	Sept. 22 to Oct. 12	Oct. 13 to Nov. 9
Weight of sisal leaves processed (cwt. per day)	..	10	12	16	20 .. 25
Range of pH value					
Filter effluent at start of working day	7·3 to 9·2	7·4 to 9·1	7·4 to 8·8	7·6 to 8·5	7·9 to 9·0
Filter effluent at end of working day	7·0 to 8·9	7·2 to 8·6	7·2 to 8·0	7·1 to 8·0	6·6 to 8·5
Factory supply (river water)	—	7·3 to 8·2	7·2 to 7·7	7·0 to 7·7	7·1 to 8·0
Average total colour (Lovibond units for 5½ in. cell)					
Filter effluent at start of working day	13·2	12·4	13·1	15·2	14·4
Filter effluent at end of working day	14·6	14·0	15·7	17·0	17·5
Factory supply (river water)	12·9	11·1	10·4	11·0	6·1

TABLE X
AVERAGE RESULTS OF OPERATION OF BIOLOGICAL FILTER TREATING WASTE WATERS FROM DECORTICATOR
Settled effluent from filter re-circulated through filter in following proportions:—

14th April to 21st May, 1948—4 parts effluent from filter; 1 part decorticator effluent.
21st May to 17th July, 1948—3 parts effluent from filter; 1 part decorticator effluent.

Rate of application of mixed liquid to filter: 60 gallons per cubic yard of filtering medium per day.

Week ending (1948)	Oxygen absorbed from acid N/80 KMnO ₄ in 4 hrs. at 26·7°C. (Parts per 100,000)		Biochemical oxygen demand in 3 days at 26·7°C. (Parts per 100,000)	
	Influent	Effluent	Influent	Effluent
April 17	33	3·6	33	3·2
April 24	40	3·4	29	2·9
May 1	35	2·5	23	2·4
May 8	35	2·8	30	2·5
May 15	33	1·8	21	0·9
May 22	29	2·8	24	3·0
<u>Averages</u>				
April 14 to May 22 ..	34	2·8	27	2·5
May 29	42	5·5	32	6·2
June 5	59	7·2	46	7·7
June 12	63	6·3	47	7·1
June 19	52	7·5	39	9·6
June 26	45	7·3	37	8·7
<u>Averages</u>				
May 24 to June 26 ..	52	6·8	40	7·9
July 3	82	20	64	21
July 10	81	23	68	24
July 17	71	18	44	19
<u>Averages</u>				
June 28 to July 17 ..	78	20	59	21

TABLE XI
COMPARISON OF POLLUTING CHARACTER OF WASTE WATERS FROM WET DECORTICATION AND FROM WASHING OF FIBRE AFTER DRY DECORTICATION

Date (1948)	Oxygen absorbed from acid N/80 KMnO_4 in 4 hrs. at 26.7°C. (Parts per 100,000)			Biochemical oxygen demand in 3 days at 26.7°C. (Parts per 100,000)				
	Wet decortication		Dry decortication		Wet decortication		Dry decortication	
	Effluent from decorticator	Washings from fibre after stirring for following period (min.)			Effluent from decorticator	Washings from fibre after stirring for following period (min.)		
		10	20	30		10	20	30
May 19 ..	116	17	14	16	88	13	9	8
June 2 ..	188	23	28	26	143	15	16	19
June 4 ..	196	26	22	20	177	22	21	24
June 8 ..	230	23	21	23	207	17	18	19
Averages ..	183	22	21	21	154	17	16	18

D.D.T.-IMPREGNATED BAGS FOR PROTECTING STORED CORN FROM INSECTS

D.D.T. dissolved in carbon tetrachloride was used to impregnate cotton bags in which insect-free corn was stored. The bags were dipped in or sprayed with solutions containing 2½, 5 and 10 per cent D.D.T. Large and small cotton bags were used and untreated bags were used for comparison. Eight bags were treated with each of the three solutions and eight were untreated. Six months after treatments the percentages of damaged grain were 8 per cent in bags treated with the 2½ per cent solution, 2.9 per cent in bags treated with 5 per cent solution, and 1.5 per cent in bags treated with the 10 per cent solution. Thirteen months after treatment the averages were 11.7 per cent of grain damaged in bags treated with the 2½ per cent solution, 3.3 per cent in bags treated with the 5 per cent solution, and 1.9 per cent in bags treated with the 10 per cent solution. Practically all grain in untreated bags was damaged at the end of six months.

—The 60th Annual Report of the Kentucky Agricultural Experimental Station, 1947, pp. 40-41.

FLUME TOW RECOVERY AND SISAL BY-PRODUCTS

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In the production of sisal fibre the leaves are passed through a decorticator in which the flesh is reduced to a pulp and separated from the fibres by a large quantity of water. According to the setting of the decorticator blades, varying proportions of the fibres are broken up and washed down the flume with the non-fibrous waste. Every effort is made to recover this "flume-tow", as it represents valuable fibre. The removal of solids from the decorticator effluent, which its recovery entails, is incidental to the purification of the effluent by biological means [1]. The latter process consists essentially in passing the effluent, previously freed from all coarse solid matter, over a gravel bed, where the finely suspended or dissolved organic impurities are disposed of by the action of bacteria. This purification is very efficient, and the water thus treated does not pollute the stream into which it is ultimately discharged; in fact it can be safely reused for the decortication of further amounts of leaf. As the amount of water used for this purpose is large, and water supplies are often limited, this reuse would, in many instances, afford a considerable advantage.

MECHANICAL METHODS OF FLUME TOW RECOVERY AND BY-PRODUCTS FROM WASTE

Of the two methods of flume tow recovery so far devised, the mechanical method of recovery is extensively practised. The pulp and fibre passing down the flume are pressed between rollers to remove excess moisture. The fibre is freed from the main bulk of the pulp on a shaking brattice and most of the residual pulp still adhering to the fibre is separated from it by carding. The tow is then dried and again carded to remove the last particles of waste from the fibre. After the flume tow has been thus recovered there still remain to be disposed of non-fibrous solids, constituting about two-thirds of the total dry matter in the sisal leaf. So far, the general practice has been to leave the waste to be carried down the flume on to a dump, whence the water, laden with dissolved or suspended organic matter, flows off, fouling the stream it eventually joins. It can be used for irrigation purposes only under favourable topographical

conditions and where ample supplies of water are available. It seldom pays to convert this old leached waste from the dump into compost and to return it to the sisal lands. The handling and transport charges over considerable distances of such a large bulk of low-value material, which will have lost much of the original contained nutrients, would hardly be economical. The waste could be dried, burned as a not very efficient boiler fuel and the ash used as a fertilizer. This has been the practice on sisal plantations in the Dutch East Indies. There, it is reported, about 13 lb. K₂O and 9 lb. P₂O₅ were thus recovered per ton of fibre produced [2]. The utilization of waste as fuel would, of course, necessitate a large drying space.

Much experimental work has been done to convert at least part of the waste pulp into marketable by-products. The African Sisal and Produce Company, Limited, and a few other firms have taken out a number of patents on the extraction of colloidal substances such as pectins and boiler detergents from the non-fibrous waste [3-12]. Pectins are substances whose gelling properties have brought them into wide use in the jam and other food industries. Their production from waste consists essentially in the extraction of soluble substances such as sugars, with water, followed by the treatment of the waste with acids and finally with alkali, from which latter extract the pectins are recovered. Boiler detergents, whose presence in boiler water prevents the formation of scale, are produced by boiling the fermented pulp with water or weak alkali until a solution of sufficient viscosity is obtained [4, 5, 6]. Gelatinous material produced by alkaline extraction of the pulp is also reported to be an effective emulsifying agent over a wide range of acidity [13]. Information is scant as to the quantities of these substances obtained per ton of fibre produced, as well as to their efficiency in comparison with similar products from other vegetable sources. The residue from the extraction of these colloidal substances can be converted into pulp suitable for the manufacture of cardboard [14, 15]. Otherwise it could be air dried and used as fuel, the ash from which could again be utilized as a fertilizer.

In Mexico and other Central American countries certain *Agave* species, such as *A. atrovirens*, are grown as a source of both fibre and sugar. Sisal, too, contains a small amount of sugars and glucosides, but it is unlikely that their recovery will ever be an economic proposition [16, 17, 18].

As far as is known, none of the by-products described above have been produced on any but an experimental scale.

FLUME TOW RECOVERY BY RETTING AND THE UTILIZATION OF THE RESULTING WASTE

"Retting" is a method by which many kinds of vegetable fibre, notably flax, are freed from the non-fibrous matter in which they are embedded. In 1938 successful large-scale experiments were carried out in Kenya to apply this method to the recovery of flume tow [19]. It is based on the fact that fibre is more resistant to the action of certain bacteria [20] than is the surrounding plant flesh. If these bacteria are allowed to act on fibrous vegetable material the fleshy parts of the plant are decomposed long before the fibre is attacked. We can exercise a certain amount of control on the process by regulating the supply of water and air which are necessary for bacterial action. Fundamentally this is the same as the making of compost only that here the rotted matter is removed by water. If this were not done a stained and weakened fibre would result. The waste from the flume is passed through a set of crushing rolls, a squeezing press and finally a shaking machine, in order to remove the greater part of the water and pulp. The half-dry tow, containing 20 to 30 per cent pulp, is then packed in large tanks, in a manner which allows the access of air. After bacterial action has set in the tanks are periodically flushed with water which carries away the decomposed matter and provides the moisture needed by the bacteria. This is continued for about one week or a little longer when the tissues and entangled pulp are reduced to a jelly-like condition. This material is removed by squeezing and washing. After drying the cuticle is removed from the flume tow by brushing. The flume tow thus obtained compares favourably in strength and appearance with that removed mechanically. The process uses large quantities of water, but this could be purified in the manner already described and reused. The only non-fibrous waste to be disposed of is the cuticle, which means that we have to get rid of only about 400 lb. of waste per short ton of fibre, whereas in the mechanical

process the air-dry waste amounts to over two tons per short ton of fibre produced. It is, of course, true that all the pectins, etc., are lost during retting, but in the type of waste that accumulates we have an ideal material for the extraction of hard waxes. Indeed, as it is likely that the waxes will prove more valuable products than the pectins and other colloidal substances, the loss of the latter in the retting process is not a serious disadvantage.

EXTRACTION OF WAXES FROM SISAL WASTE

Hard vegetable waxes are a very widely used commodity; they are important constituents of shoe, floor, motor car and other polishes, the consumption of which is considerable. The most widely used wax for this purpose is Carnauba Wax, a hard wax produced from the leaves of the palm *Copernicia cerifera*. This palm is only grown in Brazil from which country Carnauba Wax must be imported. Candelilla Wax, produced from a species of *Euphorbia* in Texas and Mexico, is also used. Raphia Wax, a product of the palm *Raffia ruffia*, which is indigenous to East Africa, does not appear to be widely used, owing probably to its low solubility in organic solvents.

The extraction of waxes from sisal waste has been investigated by the African Sisal and Produce Company, Limited [21], and also by the author [22]. In the course of the latter investigation it was found that the hard waxes were contained in the cuticle of the leaf. Now the cuticle represents only about 0.75 per cent of the weight of the freshly cut leaf and must be separated from the rest of the non-fibrous waste to make the extraction of waxes economically possible. For this purpose the flume tow retting process is ideal. Waxes can also be extracted from the waste accruing from the dry carding of flume tow recovered by mechanical means, but this waste only contains approximately 5 per cent of wax, whereas the waste from retted flume tow contains about 17 per cent. Both these percentages refer to dry waste. In mechanical flume tow recovery not all the cuticle adheres to the fibre and much of it is washed down the flume with the fleshy pulp, from which it could be recovered by a process of "controlled composting" similar to that used in flume tow retting. This, too, would yield a material with a high wax content. It should be possible to obtain 60 lb. to 80 lb. of crude wax from the waste accumulating in the production of a short ton of fibre.

Of a large number of solvents tried, benzene has been found to be the most suitable for the extraction of the waxes. The extraction is carried out with the hot solvent from which, on cooling, the hard waxes separate out in the form of a gel. If this gel is filtered off, the filtrate can be evaporated down to give a wax of a consistency similar to beeswax. It amounts to approximately 17 per cent of the total wax extracted. The gel itself still contains much solvent which must be evaporated in order to obtain the hard wax which makes up the remainder of the extracted waxes. To carry out this separation in practice is hardly worth while, and the simplest course is to evaporate the solvent from the hot extract, when a very hard, dark green crude wax is obtained. In its physical and chemical properties it is not unlike Carnauba or Candelilla wax. It can be bleached by treating the hot extract with activated charcoal before evaporation. The melting point of the crude wax lies in the region of 80°C. On prolonged heating to 100°C. the crude wax is converted into a brittle, resinous substance which no longer exhibits any wax-like properties. This may be a disadvantage in some industrial uses, but it can be readily overcome by a comparatively simple process of purification in which the fraction of the wax which is insoluble in ethyl alcohol is removed. The remaining wax no longer exhibits this undesirable change. The solubility of sisal wax in benzene should make it particularly suited for use in shoe polishes. In regard to plant and technique, the production of sisal wax should not offer any undue difficulties.

As far as is known, the extraction of all these by-products has not yet gone beyond the laboratory stage, but there is little doubt that their production, especially when coupled with the purification and reuse of water, will result in a useful and profitable "streamlining" of the sisal industry.

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PROSPECTS FOR THE UTILIZATION OF SISAL WASTE

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More than a decade ago the author wrote some articles on the utilization of sisal waste in this Journal (Vol. III, p. 423; Vol. IV, pp. 89, 343, 415; Vol. V, p. 312). Since then, considerable changes in sisal production have taken place. During the war, Java and Sumatra almost completely fell out as sisal producers; they are, however, vigorously re-establishing their former capacity and by 1953 they expect to be in full production again. In East Africa, during recent years, sisal production has been consistently considerable. As, however, very little was done to restore soil fertility, lost by continuous cropping, in many plantations with restricted land areas, falling yields have begun to be apparent, while the appearance of various kinds of physiologic and other diseases points to undesirable nutritional conditions in the soils. This makes it quite clear that the time has come to consider seriously improvements in soil fertility. Naturally, the utilization of the sisal waste as a fertilizer is of primary importance.

Another development, the extraction of various organic substances from the sisal waste, was investigated during the war in the Western Hemisphere as well as in England. The production of pectin from dried sisal tissue has now passed the pilot-plant stage, and actually a factory is under construction in Kenya to extract the pectin from 5,000 tons of dried sisal tissue every year.

The present article reviews briefly the past and the present state of the utilization of sisal waste and lays special stress on possible developments in the near future.

One point may be cleared up straight away, viz. that of edibility of sisal waste for cattle and other stock. In the literature one finds now and then mention made of the edibility of *Agave* waste. However, frequently, thereby no distinction is made between various species of *Agave*, of which there are a few hundred, though only some ten *Agave* species are commercially exploited on a considerable scale.

Some *Agave* species contain saponins to a lesser or larger extent. Sisal, i.e. the botanical species *Agave sisalana Perrine*, contains a considerable amount. It is this saponin content that makes the fresh sisal waste inedible for

stock. However, in the extraction of pectins from dried sisal tissue, the saponins are also eliminated from the tissue. The spent tissue, thus freed of saponins, is edible for stock. This may be an accessory advantage of pectin extraction from sisal waste.

Agave tequila, which in the western middle sections of Mexico is used for the distillation of the national liquor "tequila", virtually contains no saponins at all. At the pre-flowering stage its boles contain up to 15 per cent of sugar, and in the fresh state these boles are an excellent feed for cattle, horses, mules, etc. Also the fresh decorticated tissue of this species is edible for stock. The author has seen for himself, on Mexico's west coast, a Mexican who made a living of hand decorticating leaves of *Agave tequila*, feed his leaf carrier, a mule, with the fresh tissue. The same, though to a lesser degree, is true for *Henequen*, frequently less correctly called Mexican sisal, which is *Agave Fourcroyoides*, the species of the Yucatan *Agave* industry.

Though in the past, as at present, scattered use has been made of composted sisal waste, mostly unintentionally, its real full-scale use as a fertilizer started with the author's establishment in 1930 of "aqueous-manuring" in the estate practice of Sukamandi, Java. This is the term used at the Java plantation for the application of the effluent of the sisal factory, mostly combined with the effluent of the tapioca factory of the same plantation, to sisal fields which are being renovated. The name "aqueous-manuring" for this procedure seems quite appropriate because in decortication the leaf tissue is mixed with about five times its volume of water, while more water is added with the effluent of the tapioca factory. After separation of the flume tow from the effluent, all the added water reduces the dry matter content tissue plus solubles of the aqueous manure to 1.7 to 1.2 per cent.

In decortication in most sisal factories, about five times as much water is used as the volume of the decorticated leaf. This suffices for aqueous-manuring, if the soil to be manured is not of a permeable nature. However, where water soaks fast through the soil, it may be necessary to dilute the factory effluent by

another one-fifth to one-third of its volume, at least, if it has to be conducted over considerable distances through channels to the fields.

Before discussing the limitations of the practice of aqueous-manuring, its effect on sisal yield may first be considered. The author found that independently of the fertility state of the land before its being aqueous-manured the effect of the latter on fertility is great if the amount of the waste used per acre has been derived from 200 tons of leaf. The availability of so much waste, of course, implies that every acre of the whole sisal plantation, on the average, produces 200 tons of leaf during the sisal cycle. The total fibre contained in 200 tons of leaf, on the average, is about 10 tons, of which under African conditions 1.8 to 2.5 tons may be flume tow and the rest line fibre, including brushing and grading tow. The cycle duration varies somewhat with altitude and with rainfall, but for proper estate practice it may be assumed to be seven to eight years if the time required for renovation is included. As a general average, therefore, one may assume for African conditions a yield of about one ton of line fibre per acre per cycle year if proper use is made of the sisal waste as a fertilizer. How, initially, such yield can be obtained is not a point of discussion in this report. For its constant maintenance, after it once has been attained, minor chemical-fertilizer applications may be required, either for yield control proper or for rectifying possible unbalanced conditions of the soil nutrients. As a rule, however, chemical fertilizers will be required only if one wants to raise this one-ton yield to an even higher level.

The beneficial effect of the sisal waste as a fertilizer, of course, is mainly due to its nutrient content. Though great variations occur in this, especially if single nutrients are considered, it may be said that on the average healthy but not over-fed sisal, per 200 tons of leaf, contains the equivalent of about 900 lb. nitrogen, 270 lb. P_2O_5 and 1,350 lb. K_2O . In terms of the commercial fertilizers sulphate of ammonia, double duper phosphate and muriate of potassium, these quantities are equivalent to 5,700 lb. or more than 2.5 long tons. Besides nitrogen, phosphorus and potassium, many other constituents, such as lime and magnesia, which are required to a lesser extent for good sisal growth, are contained in the sisal waste. Some of the latter may be of high importance,

as normally they are present only in small amounts in the usual commercial fertilizers. Furthermore, the effect of the organic matter as such, i.e. apart from its content in plant nutrients proper, may be of considerable importance, especially by reason of its beneficial effect on the physical properties of the soil, such as its water holding capacity.

It will be appreciated how large the yield of one ton of line fibre per acre per cycle year is if one calculates the actual corresponding value from data recorded in the annual reports of the East African sisal industry. In 1947, for example, the total corresponding sisal yield of Kenya and Tanganyika Territory together was about 134,000 tons, while the corresponding total area, covered by sisal, was about 657,000 acres. This implies very little more yield than 0.2 tons per acre per cycle year, or one-fifth of the above figure of one ton. Nevertheless, it is possible under practical conditions even to surpass the one-ton yield and actually, before the war, in Java this yield was being surpassed over a large area.

Now returning to the limitations of the practice of aqueous-manuring, it is easily seen that three factors are the most important limiting ones, viz. the available quantity of water, the topography of the land and the altitude differences between the factory site and the fields to be aqueous manured.

Whereas in Java and Sumatra plenty of water is usually available for decortication and for further diluting the factory effluent, this is far from true for East Africa, especially for Kenya. In Kenya, according to the existing regulations, 80 per cent of the water used in sisal factories should be returned to its place of intake in a pure state. This, especially the latter condition, has appeared to be impossible of fulfilment and actually the considered regulations are not being enforced. However, the prospect of such enforcement is rather a menace for the Kenya sisal industry unless its water requirement can be reduced or altered. Aqueous-manuring would worsen rather than alleviate the present problem of water supply for the Kenya sisal industry.

In most parts of Tanganyika the position of the water supply for sisal factories is not so serious as in Kenya. However, if aqueous-manuring were to be practised in Tanganyika, most of the factories would have to find means for increasing their water supply and in many instances this would be difficult.

In regard to the topography of the land to be aqueous-manured, level land is easiest to deal with. Such land can be partitioned by low bunds into sections, into which the aqueous manure is led from channels. Such sections may be called plots and the application of the aqueous manure by plots may well be called "plot aqueous-manuring". The more level the land is the larger the plots can be made. However, the larger the plots, the more attention has to be paid to the even spreading of the aqueous manure, especially of the tissue. If the soil is permeable no large plots can be used because the water of the effluent would soak so fast into the soil that the farthest ends of the plots would not receive their proportional amount of aqueous manure. In very permeable soil it will even be necessary to cover the whole area with contour ditches. The corresponding aqueous-manuring may be called "ditch aqueous-manuring", and the principle of it is that the smaller the soil area covered at any moment with aqueous manure the faster is the current of the latter if its amount let in from the channel remains constant. Again, the faster the current the shorter is the time required to cover a given area and, consequently, the smaller will be the amount of aqueous manure seeping through the soil during that time.

Of course, ditch aqueous-manuring can be used on any kind of land, although it is used most frequently on soil which is too permeable for plot aqueous-manuring. Ditch aqueous-manuring has the advantage over terrace aqueous-manuring that the ridges can easily be levelled afterwards in order to make subsequent field operations independent of the limitations imposed by terraces. Plot aqueous-manuring also has this advantage.

The waste from 200 tons of sisal leaf, diluted with water at the rate of five times its volume, will cover one acre of completely level land with one foot of aqueous manure. The aqueous manure can be applied in two portions with one or a few days in between so as to allow the first portion being absorbed in the soil before the second is applied. In this case the average coverage of the land with aqueous manure will be a half foot. However, even so, there are likely to be places where the aqueous manure will stand one foot high against the plot bunds. Consequently, in plot aqueous-manuring the effective height of the bunds should be one foot. This implies that with a slope of one degree in the land the plots

should not be made broader than 60 feet. Theoretically, with a land slope of five degrees, the plots may be only 12 feet broad. Land with a five degree or even with a somewhat less slope, unless ditch aqueous-manuring is practised, should be terraced to enable it to be properly aqueous-manured. Aqueous-manuring on terraces was already called terrace aqueous-manuring.

In Java and Sumatra before the war terracing used to be performed by hand labour, which was plentiful and cheap. In Africa the labour position requires terracing to be performed with mechanical equipment. In the United States, where in recent years terracing of large areas of land has been accomplished as an anti-erosion measure, a common terracing implement is the mechanical road grader, which is now also being used in East Africa for road grading. Such a road grader, if the slope of the land is not too steep, say not more than five degrees, can be made to terrace a horizontal width of 12 feet in one operation if simultaneously it is directed to build up the required bund on the downhill side of the terrace.

Now, as long as herbicidal weeding in sisal has not reached a sufficiently perfected and economic stage, such weeding in East Africa will have to be performed with mechanical equipment such as rotary hoes, disc harrows, surface scrapers, etc. To enable such equipment to be manipulated long enough after the planting of the sisal the work space between sisal rows should be about 12 feet broad. On terraced land a horizontal space of about one and a half feet is lost in the steeply sloping terrace bank. Also, the space of say one and a half feet between the terrace edge and the nearest sisal row is a lost space for mechanical weeding. Consequently, on terraced land in East Africa, the horizontal terrace width would have to be chosen at least three feet wider than the 12 feet required on non-terraced land.

However, the wider the space between sisal rows, the smaller the population density of the sisal, and consequently the lower the fibre yield. In Java, the author found that sisal fields would still increase in yield if their plant density was raised to more than 3,000 to the acre. However, the latter density in Java is the highest limit one can allow with a view to properly operating between sisal rows for harvesting and hand weeding. In Africa, it is thought, the requirement of mechanized weed-

ing on non-terraced land reduces the workable maximum population density from 3,000 to about 2,400 plants per acre, which implies a loss in yield of 20 per cent of the maximum that could be reached were hand weeding practical or had herbicidal weeding already proved to be an effective and economic proposition.

On terraced land this reduction of 20 per cent in yield would be increased by another 20 per cent reduction through loss of planting space in terracing.

In East Africa one hears frequently the opinion being expressed that the problem of a higher or a lower sisal yield is not of much importance. That may be so as long as any quantity of sisal fibre of any quality can easily be sold at a profitable price. However, within some three years from now the East African sisal producers will begin to feel the effect of severe competition by the sisal produced in Java and Sumatra when these countries will again have reached their old standard of production. One should not forget that in regard to the production of a given quantity of sisal fibre a higher yield per planted area implies a proportionately smaller sisal area and a smaller labour force. With yield increases of 150 per cent or more these favourable factors imply a very considerable economy and lowering of the cost price of the produced fibre.

The above discussion in regard to the shape of the land may be summarized as follows:—

In Tanganyika, where most sisal land is undulating or rolling, no large areas are available for plot aqueous-manuring. Here virtually all aqueous-manuring would have to be performed on terraces or in contour ditches. Terrace aqueous-manuring does not seem to be a desirable procedure in East Africa because, owing to the requirement of mechanized weeding it would imply a considerable reduction in population density over and above the reduction of 20 per cent from the optimal density as resulting from mechanized weeding on non-terraced land. Contour ditching and aqueous-manuring in the ditches is possible virtually everywhere in Tanganyika. After the application of the aqueous manure, the ridges between the ditches can be levelled and the land will have the same surface shape as land without any waste treatment. Of course, the problem of reduction in population density by about 20 per cent from the optimal as a result of the requirement of

mechanized weeding stands with ditch aqueous-manuring as without waste treatment. The possibility of circumventing this reduction by means of strip cropping will be discussed in a later section of this article.

In Kenya the surface shape of very considerable sisal areas is well adapted to plot aqueous-manuring. The rest of the sisal land can be contour ditched. However, the existing water regulations of Kenya, if enforced, are prohibitive of any kind of aqueous-manuring. Kenya's water problem, however, can be obviated by producing the sisal waste without the use of water. Of course, the latter can also be done in Tanganyika. How the resulting problem of finishing the dry-decortication fibre can be solved will be discussed in a later section of this report.

The effect of altitude differences between the site of the sisal factory and the sisal fields on the feasibility of aqueous-manuring still remains to be considered.

The simplest case presents itself where the factory lies higher than the fields. Usually, in such cases, all or most of the fields can be reached by gravitational fluming of the aqueous manure through surface channels dug in the ground. The best slope of these channels has empirically been found to be 6 to 1,000.

However, even with the factory lying higher than all the fields, it may well happen that some hill ridges have depressions so as to exclude part of them from gravitational aqueous-manuring. Even whole ridges may be separated from the factory by valleys, and there may also be isolated hill tops. In all such cases it will be necessary first to conduct the aqueous manure gravitationally to the nearest suitable point and from there pump it up to a higher level.

Pumping stations are unavoidable in aqueous-manuring if all or part of the sisal fields lie higher than the factory, and the aqueous manure can be raised by as much as 50 feet by a pump. The required power is a small budget item. Practice has proved that a few pumping stations on one channel line are no hindrance in the operation of aqueous-manuring, neither is a distance of up to five miles from the factory to fields. However, with permeable soil and with long conducting channels, considerable allowance has to be made for seepage of aqueous manure through the soil. Under such circumstances it will be

necessary to dilute the factory effluent with water, possibly amounting to as much as 50 per cent of the original volume of the effluent.

The utilization of the sisal waste in undiluted form, which is made possible by dry decortication of the leaves, solves all problems in regard to terracing, contour ditching, pumping of the aqueous manure and dilution of the normal factory effluent. It can also solve the problem of water availability to some extent, particularly the kind of water problems found in Kenya.

STRIP-CROPPING IN SISAL PLANTATIONS

Strip-cropping is an agronomic system which in the United States is being used as an anti-erosion measure. Theoretically, on a slope, one may maintain pasture or a hay crop on contour strips of varying width and alternate these erosion-preventing crops with strips of erosive crops such as maize. The soil washed down from the maize strips is caught by the grass strips. Gradually, something like natural terraces will be formed at the place of the erosive strips, while the anti-erosion strips become terrace banks, either gently sloping or steep, according to whether one has chosen them broad or narrow.

The accessory crops that can be chosen in strip-cropping with sisal may be annuals adapted to the soil and climatic environment of the particular plantation considered, e.g. maize, sun flowers, millet, ground nuts, soya beans, various other bean species, pyrethrum, annual cotton, etc. In regions with two distinct rainy seasons per year one might sow the annual accessory crops twice a year. One might choose varying accessory crops for various years for various seasons for various parts of the plantation, as might appear most desirable according to rainfall, soil conditions, marketing situations, etc.

It is also possible to choose perennials as accessory crops, e.g. perennial cotton, low pruned kapok of the permanent-branched type, perennial bast-fibre plants, perennial essential-oil plants such as patchouli, ginger grass, palma-rosa grass, etc. Other possible accessory crops are of the semi-perennial type such as citronella grass, cassava, and rotenone plants such as Derris and Lonchocarpus. Of course, pasture or hay strips can be used as accessories.

Some of these accessory crops in sisal are erosive, others are anti-erosive. With the

former ones it will be necessary to draw and maintain shallow or deeper ditches on the borders of the accessory strips with a view to catching the washed-down soil and to preventing gully formation. If the accessory crop is very erosive narrow strips of weeds will have to be maintained on either side of the accessory strip. If, however, erosion can be prevented without the use of weed strips the latter should be avoided because they are a continuous source of contamination with weed seeds of those parts of the land where weeds are not wanted.

A bast fibre as accessory crop in sisal may be a very desirable choice as some of the routine operations for bast fibres are the same as for sisal or are very similar. The production of bast fibres on a large scale in East Africa, apart from being an important agronomic assistance in sisal production, not only would be of high economic importance for the country as an additional source of revenue but also would be of great strategic value, as under emergency conditions it could completely supplant jute, whose production source is Bengal.

Urena lobata, a perennial bast fibre species, is to some extent grown in the Belgian Congo. Recently, it has been introduced into Kenya by the Kenya Department of Agriculture. However, whether this species is sufficiently adapted to the not-too-high rainfall of most of the East African sisal plantations remains to be seen.

Ramie may be grown in strips between sisal on those few sisal plantations of East Africa where the rainfall suffices for the rather exacting moisture requirements of ramie.

In Tanganyika I found a very common weed called "Uvuvundi" by natives, which yields a beautiful bast fibre that can be separated from the stalks by retting in water for about 15 days. The botanical name of Uvuvundi is *Sida acuta* Burm. The fibre content of its stalk is high, and its fibre is soft, fine, regular and strong. Under cultivation its stalks would probably reach five to seven feet in length. If grown close planted its branching would probably not be excessive. Selection would reduce natural branching hereditarily. This species is perennial. It might be cut twice a year and its cutting might be arranged so as just to precede the semi-annual sisal cuts. Machines could be constructed, or may even be available now, which could de-wood the stalks in the field so as to reduce the transpor-

tation load of the stalks by 70 per cent to 80 per cent. Simultaneously the retting space for the bast would be greatly reduced compared with that required for retting the whole stalks. Furthermore, the retting of the bast alone last only about 50 per cent as long as that required for the whole stalks. A strip of Uvuvundi about six feet wide grown in contour rows, with a crowded spacing within the rows, would be one of the finest anti-erosion protections imaginable.

It is easily visualized that accessory crops in strips, alternating with double or single sisal rows, would make available during a considerable part of the year a considerable space for the operations of cutting the sisal and weeding the land. At such times of the year as annual strip crops would be off the land such space would be abundant. Some annual crops such as ground nuts, soya beans, etc., are short throughout the whole of their growing period and would yield very little obstruction to operations between their own strips and the sisal rows. The same would temporarily be the case with such perennial accessories as are cut near the ground, as e.g. Uvuvundi. Even in their full grown stage, accessory crops like Uvuvundi would be far less obstructive to mechanical weeding than another row of sisal would. Sisal leaves stand out with their tips as far as five feet from the centre of their boles, while Uvuvundi would stand almost straight up.

Therefore, if, for example, double sisal rows, three feet apart spaced $2\frac{1}{2}$ feet within the rows, would alternate with accessory strips, nine feet away from the nearest of the two sisal rows, sufficient space would be available for mechanically weeding the space between the sisal rows and the accessory strips.

This double-row system is equivalent to a sisal-population density of about 3,000 plants per acre, and the single-row system has only five per cent less density. The author believes that this disadvantage of the lower density in the single-row system is far outweighed by its advantages in regard to cutting and weeding, especially with mechanical weeding.

Here then would be a sisal spacing which, in combination with strip-cropping, would approach the ideal.

It is easily visualized that strip-cropping needs no terracing of the land. If the accessory crop is anti-erosive, strip-cropping even can obviate the desirability of terracing.

Also, it is easily visualized that strip-cropping easily can be fitted into the system of plot or ditch aqueous-manuring and equally into the system of utilizing dry-decortication waste as fertilizer.

According to the author's opinion the most promising proposition is to apply strip-cropping in conjunction with the utilization of the dry-decortication waste as fertilizer.

DRY DECORTICATION

Though one might be inclined to consider the ordinary decortication with water as a combination of the two operations, decortication without water and flushing with water, and it has been proved that an interaction takes place between the process of decortication and the simultaneous flushing with water.¹ If, after the dry decortication, one flushes the dry-decortication sisal fibre with water subsequent sun drying will not properly bleach the processed sisal fibre. The fibre will be greyish as a whole, while towards the top end of the hanks it will be greenish. The causes underlying the appearance of these greyish and greenish colours are eliminated by the water if it is applied during the decortication, but not if the flushing occurs afterwards.

More than twenty years ago the author investigated various methods of properly finishing dry-decortication sisal fibre. A few of those methods were found quite promising. However, excepting the method of double decortication, none of these methods were given a protracted large-scale practice test because, in Java, the aqueous-manuring procedure, which requires no dry decortication, appeared to be a satisfactory solution for the Java problems of soil fertility in sisal plantations.

The finishing methods referred to above may be distinguished as:—(1) biologic, viz. by retting; (2) physical, viz. by heat treatment and by solvent extraction; (3) chemical, viz. by oxidation and/or reduction or by other treatment, and (4) by double decortication, i.e. by decorticating the sisal leaf without the use of water and immediately thereafter decorticating the dry decortication fibre with the use of water.

The principles underlying these methods are elimination or destruction of the organic substances by whose presence originates the discolouration of the dry-decortication fibre, or

by inactivation of the enzymes whose reactions form an essential link in the occurrence of this discolouration.

By retting dry-decortication sisal fibre it appeared that a perfectly white fibre can be obtained. It is best, before the retting, to thoroughly flush the dry-decortication fibre with water. Hereby, the saponins which counteract retting until they are themselves decomposed during the retting process, are eliminated and consequently the retting proceeds faster. If after the flushing the retting is performed without renewal of the retting water the retting proceeds faster than with water renewal, but the finished fibre will not be pure white and will be dull.

However, if the retting water is continuously being renewed in a counter-current system the retting will last about twice as long. Though the finished fibre will be pure white, it will be unusually soft on account of the protracted contact with water. Fibre softness may be appreciated for specified purposes by some buyers of sisal fibre, but the large buyers of the U.S.A. prefer the stiffer sisal fibre, at least to a very large extent.

So far it has been assumed that the retting water is pure, but most of the water available in East African sisal plantations is contaminated with suspended foreign matter and discoloured by soluble organic compounds. To obtain by retting a pure white fibre, most of the available water in East Africa would have to be chemically treated and filtered previously, sand filtering probably sufficing.

It will be seen, therefore, that retting of the dry-decortication sisal fibre is not a generally practicable solution for the problems of finishing dry-decortication fibre. However, it may work economically under limited conditions.

By heat treatment of the dry-decortication fibre not only are the enzymes inactivated but also the tissue attached to the fibre is softened, so after sun drying it can be brushed off. Heat treatment can be applied by high-temperature water, by steam or by other hot vapours. The author thinks that heat treatment can be developed into an effective and cheap finishing method, but some research would be required to standardize it properly.

Solvent extraction of dry-decortication fibre yields a beautiful finished product if the extraction is performed continuously in a counter-current system. The used solvent, e.g.

alcohol, which is loaded with suspensions and solubles, can be distilled off from the suspensions and solubles and can be re-used, so little solvent loss will be incurred. The main contents of the loaded solvent are chlorophyll, xanthophyll, carotin, saponin, etc. These can be recovered in a pure or semi-pure state and can be marketed. If this is done, it would be best not to flush the dry-decortication fibre before extraction, so as to lose nothing of the mentioned substances in the flushing water.

As the operations involved in solvent extraction require a high standard of equipment and personnel, it does not seem that this method of finishing dry-decortication fibre would be practical for any existing East African sisal plantation unless the extraction of pectins, waxes, etc., from the total waste were undertaken at the same time. For this purpose a sisal factory would be converted into a complete chemical plant. For the time being, however, this will remain one of the *pia vota* of the sisal industry, though no technological problems stand in the way of its realization.

It may well be mentioned here that sisal wax, which in quality stands close to carnauba wax, is contained in the epidermis of the sisal leaf, the wax being extracted from the epidermis by means of solvents. The wax extraction will be the more economic and the quality of the wax the better the purer the epidermis material that undergoes the extraction.

It happens that in dry decortication the shredded pieces of epidermis accumulate in an almost pure state on the top of the undiluted dry-decortication waste. They can easily be separated from the rest of this waste by sieving, at least in the case of the waste obtained from the first knife drum. Thereafter washing with water in a simple apparatus will yield the pieces of epidermis in a pure state. Incidentally, it may be mentioned here that in the Western Hemisphere a wax-recovery method has been worked out in which the sisal leaves, previous to decortication, are drawn through a solvent bath which extracts the wax in a pure state. The author believes, however, that the mechanical separation of the shredded epidermis from the dry-decortication waste and subsequent solvent extraction of the wax is preferable over the method of extraction previous to decortication, especially because in the former system the plantation participation in the wax processing is confined to the mechanical separation of the epidermis pieces.

while the solvent extraction can be left to a central chemical plant.

Several of the chemical methods of giving a final finish to dry-decortication fibre appeared to be effective and, if properly performed with the minimum quantities of chemicals during the shortest effective time of treatment, they did not impart any undesirable property to the final product. One of the most desirable chemicals for the considered treatment appeared to be oxalic acid.

It would be worth while to study various recent developments in synthetic or semi-synthetic detergents, e.g. the sulphonated-oil types. The author took care that samples of one of the new detergents, viz. Santomerse No. 1, manufactured by Monsanto Chemical Company, was forwarded to Kenya to be tested as a finisher of dry-decortication fibre.

It would take far too much space to discuss all the chemical treatments already tested by the author. Also, for any of them more tests would be required, especially large-scale tests under practical conditions in order to reach final decisions. However, it cannot be doubted that it is possible to chemically finish dry-decortication sisal fibre in a perfectly satisfactory and economical way. In most East African sisal factories, however, considerable improvements in qualification of the personnel, especially of the supervisory personnel, would be required for entrusting same with chemical-treatment finishing.

The fourth and last of the above enumerated methods studied by the author for finishing dry-decortication sisal fibre is the method of double decortication. Double decortication has already been referred to and it has been stated that by means of it a perfect sisal fibre can be obtained. It is an amplification of dry decortication. The latter has already been discussed and it will have been understood that the real aim of dry decortication is the obtaining of undiluted sisal waste with the main object of utilizing the latter as a fertilizer. So far no mention has been made of how to transport the undiluted sisal waste to the fields and how to apply it there to the soil.

As the sisal leaf, on the average, contains only five per cent fibre, inclusive of waste tow, it is self-evident that dry-decortication waste does not weigh more than 95 per cent of the leaf. Also, it will easily be visualized that the volume of the dry-decortication waste is somewhat smaller than some of the leaf as loaded

on rail trucks. Therefore, the problem of returning dry-decortication waste to the sisal fields is much the same as bringing the sisal leaves to the factory. The slope of the rail tracks may be less favourable for the returning of the waste than for bringing in the leaves, but it does not seem that in most of the sisal plantations this would be a serious obstacle.

Without considering details which vary according to places, little objection will be met if it is contended that, generally, the returning of the dry-decortication waste to the sisal fields and spreading it between the sisal rows will not be found more expensive than the bringing of the leaves to the factory, inclusive of the cutting, bundling and loading into the rail trucks. If in the sisal factory the dry-decortication waste is conveyed mechanically into a hopper after the extraction of the waste tow and maybe other substances and dumped from the hopper into boxes standing on the rail trucks which brought the leaf from the field, and if the same locomotive brings these trucks to the field from where they will bring new leaf to the factory, the transportation of the dry-decortication waste will imply very little additional expenditure over the normal for leaf transportation. The application of the dry-decortication waste is best done in ditches, dug mechanically near the middle of the wide space between sisal rows. After this application the ditches should be covered with soil. The ditches should not always be dug at the same place in order to avoid undecayed waste being turned up. In semi-annual applications, i.e. applications after each semi-annual cutting, three locations of the ditches in or near the middle of the space will suffice. The waste thus will have one and a half year's time for properly decaying.

Without indicating details, it may be said that the application of the dry-decortication waste from the rail trucks into the ditches between the sisal rows could very well be completely mechanized.

From the above considerations it follows that the basis for estimating the costs for transporting the dry-decortication waste to the sisal fields together with same for application between the sisal rows is given by the budget item for cutting, bundling, loading and transporting the sisal leaf. In East Africa this item seems, generally, to be about Sh. 60 per ton of line-fibre outturn. This maximal figure for dry-decortication waste in regard to its trans-

portation and application in the sisal fields should be compared with the value of dry-decortication waste as fertilizer.

It has already been explained that for every ton of line-fibre outturn from the factory one removes one-third of a ton of commercial fertilizers from the sisal fields, if nitrogen, phosphorus and potassium only are considered. One-third of a ton of commercial fertilizers, inclusive of transportation and application, now costs about Sh. 160. The total value of the dry-decortication waste considerably surpasses this figure, which compares with Sh. 60 for its transportation and application. Actually, the utilization of the dry-decortication waste, on the average, will make a five-fold rise in sisal yield in East Africa possible. The smallest rise, locally, will be two and a half-fold. Such yield increases, accomplished with little expenditure, will very considerably lower the cost price of the manufactured sisal.

There is another value in the utilization of sisal waste. If one does not utilize the waste as fertilizer but one applies commercial fertilizers, the latter, in so far as absorbed by the sisal plants, are thrown away in the sisal waste, i.e. one has to pay the full price for them each time one applies them. If, however, the sisal waste is utilized as fertilizer, the applied commercial fertilizers are also applied anew, together with the waste. On the average, allowing for losses, the commercial fertilizers then will cost only one-fifth of their market price.

Now returning to double decortication, worked out by the author more than 20 years ago, one of its advantages in the factory is that it allows a wider adjustment of the knife drums from the concaves than is possible in ordinary single decortication. This applies to the first of the two decortications in double decortication. It implies that a smaller proportion of the total leaf-fibre becomes waste tow. In the second, i.e. the wet decortication of the double decortication, virtually no fibre goes into the waste at all. Consequently, double decortication makes possible a higher line-fibre recovery than can be attained in single decortication. This was proved conclusively in a double decortication pilot plant, run during more than six months.

In double decortication the dry-decortication fibre, turned out by the first decorticator, can be fed automatically into the second decorticator, but the second decorticator can finish far more fibre than is turned out by the

first decorticator. In Java, where in ordinary decortication a No. 4 Corona is adjusted to decorticate about eight tons of sisal leaf per hour, one such Corona can be fed with the outturn of three dry-decortication No. 4 Corona's. In Africa, where in ordinary decortication a No. 4 Corona is usually adjusted to decorticate thirteen tons of sisal leaf per hour, only two dry-decortication Corona's could be used to feed one wet-decortication Corona. Whether in East Africa the slow Java or the fast African feeding is the most economic system of decortication is a problem that might well be worth investigation but, unfortunately, very few sisal factories in East Africa have reserve decorticators.

However, the feasibility of dry/wet decortication was greatly improved recently when it was discovered that it is possible in a modified ordinary Corona with only two knife drums. Such a modified Corona, if built new, and optimally adjusted to dry/wet decortication, is estimated to cost only about 20 per cent more than an ordinary Corona. With simpler mechanical adjustment extra costs would even be considerably lower. Also, in the latter case, it is possible to modify existing Corona's and adjust them to dry/wet decortication.

The principle of the newly invented dry/wet decortication is to divide the rotating surface of the knife drums into two watertight partitions by a band in the middle of the rotating surfaces. In each knife drum, that section where the sisal leaf is introduced first receives no water. The second section of each knife drum, in which the dry-decortication fibre is finished, receives water through the concave. The water outlet from the wet-decortication partition is arranged so as to let no water be mixed with the waste coming from the first partition.

This simplest form of dry/wet decorticator can be elaborated, such as by broadening the rotating surface of the knife drums so as to make more space available for making it watertight and, possibly, for broadening the two partitions of each knife drum, or one of them. Of course, the optimal construction of the new dry/wet decorticator is not a point that will be settled in a few days. But the practical possibility of dry/wet decortication is there, and the author believes that adjustment of the East African sisal industry to the new possibility of dry/wet decortication will be a very wise procedure.

Of course, a complete East African adjustment to dry/wet decortication will not be a work of a few months or even a few years, therefore it is the author's conviction that, meanwhile, the practice of dry decortication with ordinary decorticators, combined with a chemical or, possibly, a physical method of finishing the dry-decortication fibre, would be a very wise temporary procedure. To make the best of the suggested finished methods it will be necessary to investigate them further.

In recent discussions with sisal brokers in New York the author was again confirmed in his opinion that the large United States sisal buyers do not attach a high importance to difference in general value of the East African No. 1, 2 and 3 grades on the one hand and A, B and C grades on the other. This, actually, constitutes the difference in quality between dry decortication and ordinary East African sisal fibre, if both are treated equally after decortication, excepting that the dry-decortication fibre is flushed with water immediately after decortication.

These large buyers will, of course, require the best quality of fibre for the price they are prepared to pay. However, in regard to colour of East African sisal fibre their primary concern is price, not appearance. The price difference, incumbent on the quality difference, above referred to, currently is one-quarter U.S. cent per lb. on the average. The attitude of these large U.S. buyers is confirmed by the fact that the U.S. demand for No. 3 L far surpasses its supply. The reason is that on the average No. 3 L is sold one-eighth of a U.S. cent per lb. less than A grade.

Therefore, temporarily producing more A, B and C grades against less No. 1, 2 and 3 grades may not be a bad procedure if the disadvantage of the lower price obtained is considerably outweighed by the advantages of dry

decortication, viz. the utilization of the dry-decortication waste as fertilizer and possibly the production of sisal wax, pectins, etc. Actually, the urgency of improving soil fertility in many East African sisal plantations is so evident that in such cases the utilization of dry-decortication waste may be considered an economic necessity. If in these cases the only way of dry decortication would be the temporary abandoning of the manufacture of No. 1, 2 and 3 grades, this might well be considered as an unavoidable temporary necessity. Of course, for the future, the aim should be to produce the highest possible proportion of the highest sisal grades that can be manufactured economically. In the meantime, research and practice should fully be directed towards this aim.

Finally, summarizing this article, it appears that an ideal state of an East African sisal plantation should be determined by the following procedures:—(1) dry/wet decortication; (2) separation from the dry-decortication waste of the shredded pieces of leaf epidermis for solvent extraction of the sisal wax; (3) possibly, extraction of pectins and other organic substances from the dry-decortication waste; (4) utilization of the dry-decortication waste as fertilizer; (5) growing of accessory crops, as e.g. Uvuvundi, in conjunction with sisal in strip-cropping; (6) planting of the sisal and of the strip crops on contour, simultaneously arranging effective anti-erosion measures; (7) using a high population density of the sisal, say, not far from 3,000 sisal plants to the acre.

If these procedures are combined with effective weeding and with a semi-annual, sparing cutting-system, the East African sisal industry will be in a position to stand the impact of the marketing competition that may be expected in a few years.

THE CONTROL OF ANTESTIA IN COFFEE

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There may be said to be three rival methods for the control of Antestia in coffee in East Africa—arsenite baiting, pyrethrum dusting and D.D.T. spraying. The first dates back to 1924 (Ritchie, 1924) and is still in general use in the Northern Province of Tanganyika; the second dates from 1936 (Notley, 1936 A) and the third is quite recent, having been developed only in 1947 (Notley, 1947).

Other methods suggested for Antestia control have not stood the test of time. Hand-picking (that is the collection of Antestia by hand), though popular for many years, received its final blow when it was shown conclusively that reasonable control by this means was only obtained at prohibitive cost (Le Pelley, 1935). Pyrethrum extract spraying (Le Pelley, 1933) was abandoned for pyrethrum dusting, and pyrethrum emulsion spraying (Notley, 1933) never found favour with coffee planters. Kirkpatrick (1937) discusses the various methods in use at that time and suggests that arsenite bait should be used in areas such as Kilimanjaro, where Corioxenos (*Stylops*) is present, and pyrethrum powder in areas where it is not. It was later shown, however (Notley, 1941), that the use of pyrethrum did not appear to affect the percentage of Antestia infested with Corioxenos.

A notable feature about all three of these methods is the paucity of published figures on the degree of control obtained. This paper is an attempt to give some figures on the various methods of control which have been tried at the Coffee Research Station, Lyamungu, during the past ten years.

ARSENITE BAITING

So far as I can find, no figures of field experiments on the effect of arsenite bait have ever been published. This is, I think, due to the method having been developed before a practical method of assessing a field population of Antestia was developed; later, when the method of spraying a random sample of trees with pyrethrum extract was developed for this purpose (Le Pelley, 1932) attention was concentrated on pyrethrum to the exclusion of arsenite baiting.

A field experiment was carried out in December, 1948, where an average infestation

of 8.7 Antestia per tree was present. There was practically no crop on the trees; the area had recently been very weedy, but had been weeded; and the trees fairly heavily pruned. The percentage kills on the three plots treated with arsenite bait were 64.4, 60.9 and 72.4 per cent, an average of 65.9 per cent, from one application; the usual recommendation is three successive applications. A further experiment gave a percentage reduction of 68.3, whilst a similar experiment in February, 1949, gave a percentage kill of 87.2 per cent.

In Tanganyika the recommendation has been to test spray immediately after any control measure to determine the degree of control obtained, and thus to compare one method against another. This was done in the experiments quoted above. This is theoretically sound; but in practice at the Coffee Research Station the routine method of Antestia control has been to test spray all the blocks about once a month or once in six weeks, and to treat all blocks with an average of more than one per tree. These treated blocks are not usually tested again until the whole station is again tested: treatment may be delayed a week or more after the first test spraying, thus the second test may be three to five weeks or more after the treatment. The result of this is that the natural increase of the Antestia left after the treatment may often obscure the effect of the treatment. In many ways this is objectionable, but where there is a marked residual effect from the treatment, this is given full value by the routine in use. This will appear more clearly in the section on D.D.T.

During most of the year 1944 pyrethrum was unobtainable at the Station, and arsenite baiting was used exclusively. On 30 separate plots the average infestation was 1.16 per tree at the beginning of February: these plots were all treated three times; between the 18th and 26th March, the 31st March and 6th June, and the 9th June and the 20th June. At the end of that period the infestation averaged 1.06 per tree. It is not suggested that the treatment had no effect—on the contrary the infestation would probably have been much greater had no treatment been applied—but it is clear that the treatment only kept the infestation at its original level, the reduction (8.6 per cent)

being negligible. The year 1944 was one of high rainfall (72 inches well distributed) and in his annual report Gilbert states that "Sodium arsenite bait proved quite inadequate to control Antestia under these conditions. Moreover, much damage was done to the trees by scorching. In the absence therefore of first grade pyrethrum powder for dusting, a large part of the crop was damaged; out-turns in some areas only yielding seven per cent clean coffee to cherry".

The present cost of arsenite baiting is about Sh. 1.50 per acre for one application for materials.

PYRETHRUM DUSTING

The first field test on pyrethrum dusting, using undiluted finely ground pyrethrum powder (Notley, 1936 A) gave a kill of 98.6 per cent. A further series of tests (Notley, 1936 B) showed that with varying applications of dust the following percentage kills were obtained:—

5.00 gms. per tree	94.2 per cent kill
3.75 gms. per tree	71.0 per cent kill
2.50 gms. per tree	45.6 per cent kill
1.25 gms. per tree	38.6 per cent kill

Later, at the Coffee Research Station, when the plots treated were tested within a few days of treatment, kills varying from 75 per cent to 100 per cent were obtained with the full application of 5 gms. per tree, or 7 pounds per acre.

This appears to be very satisfactory, but when the testing is delayed considerably after the treatment, a very different picture is obtained, due to the increase of the Antestia left after treatment. Pyrethrum has no residual effect, probably even less than arsenite bait.

The figures in Table I illustrate this.

With one exception (September–November, 1944) these figures of percentage reduction tend to be inversely correlated with the interval between tests. Some of the poor results

obtained may have been due to poor quality pyrethrum.

Another way of expressing this is to record the number of times that particular plots required treatment; this will depend both upon the percentage reduction obtained by treatment and the rate of increase of the Antestia which remain, assuming there is no immigration from outside the plot. From September, 1944, to April, 1945, out of 36 plots, it was found necessary to apply pyrethrum dust, because the Antestia had exceeded an average of one per tree, as follows:—

	Plots
Not treated	4
Treated once	13
Treated twice	9
Treated three times	9
Treated six times	1

This gives an average of 1.78 treatments per plot in seven months.

The speed with which Antestia recovers from a severe reduction in numbers after treatment with pyrethrum, particularly during the hot weather December to March, is a serious drawback to this method of control.

The present cost of pyrethrum dusting is about Sh. 9.50 per acre for materials.

D.D.T.

The use of D.D.T. for the control of Antestia is a comparatively recent development on the Station, dating from early 1947. (Notley, 1947.) Field experiments at this time showed that the use of a 0.1 per cent emulsion, applied at 80 gallons per acre, resulted in a reduction of Antestia by 100 per cent. Eggs are not affected by this treatment, but the residual effect of the D.D.T. is sufficient to kill the nymphs after hatching. It was shown that leaves sprayed in the field with the 0.1 per cent emulsion and collected ten days later were still lethal to adult

TABLE I

Date Treated	Number of Plots Treated	Infestation per Tree		Percentage Reduction	Interval between Tests (days)
		Before Treatment	After Treatment		
January, 1944 ..	4	2.15	1.18	45.4	17
September–November, 1944 ..	8	2.26	0.36	84.0	46
January–February, 1945 ..	11	1.71	1.47	13.8	28
February–March, 1945 ..	17	1.95	0.41	78.9	16
February–March, 1945 ..	6	1.53	0.60	60.9	19
March–April, 1945 ..	11	2.16	1.36	36.7	26
September–October, 1945 ..	7	2.07	1.97	4.8	34
January, 1946 ..	23	3.18	2.72	14.5	33

TABLE II

Date	Number of Plots	Infestation per Tree		Percentage Reduction	Interval between Tests (days)
		Before Treatment	After Treatment		
January, 1948 .. .	11	2.81	0.33	88.2	35
January, 1948 .. .	27	1.45	0.21	85.5	35
February-March, 1948 .. .	5	0.44	0.04	91.0	24

Antestia despite light rain (0.24 inches) but that this residual effect could not be demonstrated fourteen days after spraying.

The more striking effect, however, is in the residual effect of the treatment as shown by the method of routine testing some time after treatment, as has been described above for arsenite baiting and pyrethrum dusting.

The figures in Table II were obtained.

The spraying in February–March requires explanation. As a routine spraying with Bordeaux mixture was being carried out and Thrips was showing signs of activity, D.D.T. emulsion was included in the spray at varying rates. Of the various plots which were sprayed at the normal concentrations of 0.1 per cent D.D.T., only five showed infestation with Antestia before spraying and these are the only plots included above, and only one of these at a figure (1.1 per tree) which justified spraying.

The essential point is that one spraying of the D.D.T. emulsion in January over the whole area showed such lasting results: as has been seen, only one plot showed an infestation two months later which justified a second spraying, and although the situation is complicated by the use of D.D.T. (mostly at 0.5 per cent) against Thrips, as a whole the Station remained free from serious Antestia for the remainder of the year. The year was one of rather light rain (49 in.) and moderate crop.

The cost of this treatment with D.D.T. is about Sh. 6 per acre for materials.

Very recently a new development of the D.D.T. emulsion spray has been published (Notley, 1949); this is the use of D.D.T. emulsion at greater strength, 1.0 per cent to 0.25 per cent, applied with small hand sprayers at only eight gallons per acre. The method was devised for use in native coffee plots where expensive apparatus is not available and

the use of large quantities of water may present difficulties. The following results were obtained from this treatment at Bugufi, testing the trees immediately before and two or three days after the treatment:—

TABLE III

Con- cen- tra- tion per cent	Applica- tion per acre	Infestation per Tree		Percent- age Re- duction
		Before Treat- ment	After Treat- ment	
<i>Gallons</i>				
1.0	8	32.8	1.8	94.5
0.5	8	32.8	12.8	61.0
0.25	8	32.8	7.8	76.2
0.5	16	33.6	0.6	98.2
0.25	32	33.6	4.4	86.9
0.125	48	33.6	1.8	94.7

It appeared from these rather rough tests that the method showed promise, and further experiments were carried out under controlled conditions at Lyamungo Coffee Estate, near the Coffee Research Station. The results were as follows:—

TABLE IV

Con- cen- tra- tion per cent	Applica- tion per acre	Infestation per Tree		Percent- age Re- duction
		Before Treat- ment	After Treat- ment	
<i>Gallons</i>				
1.0	8	6.36	0.60	90.6
0.5	8	6.36	1.28	79.9
0.33	8	6.36	1.04	83.7
0.25	8	6.36	1.16	81.8
0.25	8	8.7	3.0	65.5

At the lowest concentration and dosage, 0.25 per cent and eight gallons per acre, the results are as good as those obtained from arsenite bait, the cost of materials slightly less than that of arsenite baiting, and the residual effect of this hand-spraying method is likely to be greater, though this has yet to be tested over a reasonable period. The method is not as effective as the previous one, that is of spraying 0.1 per cent D.D.T. at 80 gallons per

acre, but it recommends itself to more primitive users as an alternative to arsenite baiting with certain advantages: there are obvious disadvantages in the wide distribution of arsenite of soda amongst primitive people, and, further, the D.D.T. spray, once popularized, can be improved (though at greater expense) by increasing the concentration or application per acre.

At the moment a further modification of the method is under trial. The 0.1 per cent emulsion spray is applied at the rate of 24 gallons per acre with knapsack sprayers. The cost of materials is considerably less than the method using 80 gallons per acre, and the labour charges are lower; one man and a boy can spray about three acres a day. Great care has to be taken, however, in judging the amount of spray applied. The results obtained on twelve plots are as follows:—

TABLE V
NUMBER OF ANTESTIA PER TREE, AVERAGE FOR ALL PLOT

Before Treatment	After Four Days	After Seven Days	After 21 Days	After 42 Days
0·70	0·08	0·08	0·12	0·11
Percentage Reduction	88·1	88·1	83·3	84·5

The cost of materials for this method is about Sh. 1/80 per acre.

The use of D.D.T. for the control of Antestia has come in for some criticism, as is to be expected. Melville (1949) confirms that the 0.1 per cent D.D.T. emulsion is efficient, but suggests D.D.T. wettable powder or Agrocide wettable powder as alternatives. No figures are given for cost, or for the relative efficiency of these two substances as opposed to D.D.T. emulsion, but it appears that the use of Agrocide would be far more expensive. He expresses the fear that the residual effect of D.D.T. might effect the biological complex, and in this connexion it is important to remember that the mealy bug (*P. coffeeæ*) which has in the past been a serious pest of coffee in the Central Province of Kenya, depends for its control entirely on introduced parasites. This mealy bug, however, does not

exist in the Northern Province of Tanganyika. Taylor (1945), working in Uganda, states: "It is necessary to decide between biological methods on the one hand and chemical on the other. The two cannot be combined", and states that in Uganda native coffee plots chemical control is impracticable. It has been clearly shown that in plantation practice biological control results in too great a loss of coffee to be relied upon, therefore chemical control is essential. If this is so, the most efficient method of chemical control must be used, irrespective of its effects on the biological complex. Both views, as stated above, are probably too sweeping; chemical control methods should be chosen which do not greatly interfere with biological control, and so far at the Coffee Research Station no untoward effects on these lines in the use of D.D.T. have been observed; that is to say that the continued use of D.D.T. has not resulted, as might have been feared, in outbreaks of other insect pests in the coffee.

I am indebted to the staff of the Coffee Research Station, particularly to Mr. J. K. Robertson and Mr. L. M. Fernie, for placing at my disposal the Station records on Antestia control.

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OBSERVATIONS ON LATERAL SCOUR IN THE KUJA RIVER, KENYA

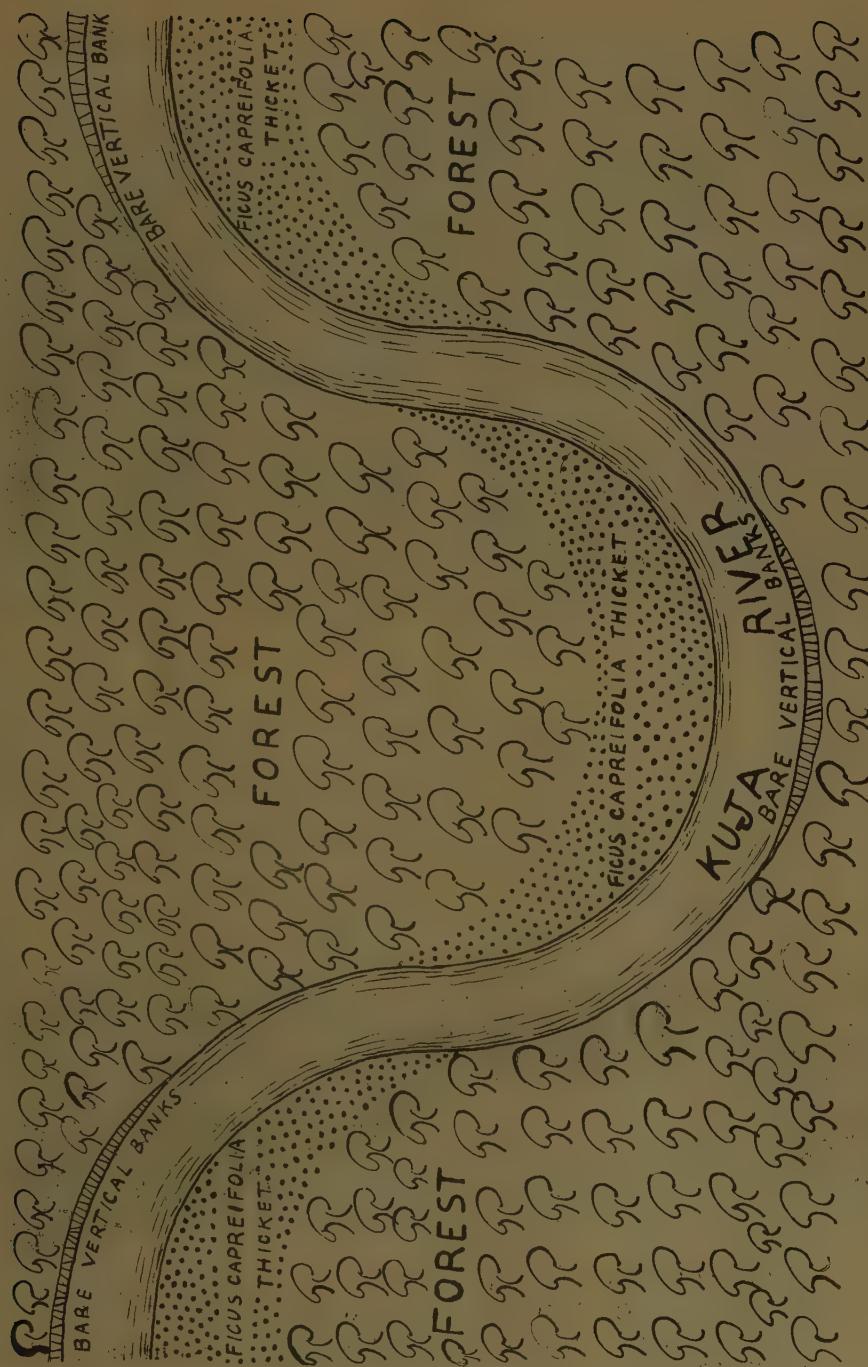


FIG. 1—Diagram of a typical bend in the Kuja River. Lateral scour can occur only in the places marked "bare vertical banks".

OBSERVATIONS ON LATERAL SCOUR IN THE KUJA RIVER, KENYA



Fig 2



Fig 3

FIG. 2—A bare vertical bank in Block VII. The tree is an *Albizia coriaria*. When it finally falls it will carry a large lump of soil into the river with it.

FIG. 3—A bend of the river in the lower clearing. The arrow points to the erodable part of the bank.

OBSERVATIONS ON LATERAL SCOUR IN THE KUJA RIVER, KENYA

By J. P. Glasgow and B. J. Duffy, East African Tsetse Reclamation Department

(Received for publication on 14th February, 1949)

By "lateral scour" we mean that type of soil erosion which is brought about by the tendency all rivers have to wash away their own banks.

The observations recorded here were made in the South Nyanza District, in approximately lat. $0^{\circ} 50' S.$ long. $34^{\circ} 24' E.$ This is close to the point where the Kaniadoto ferry crosses the Kuja River.

Some years ago, in connexion with tsetse fly experiments, we removed the evergreen riverine forest completely on five miles of the Kuja River in this locality. This woody vegetation was replaced by a grass cover, chiefly of *Cynodon* sp. which we planted. It was obvious that lateral scour was going on in certain places, and we naturally wondered what would be the effect of our clearings on this process. General opinion, we found, was divided. On the one hand, it was said that the removal of bush promoted erosion, and that the roots of riverside trees bound the bank very firmly. On the other hand, it was claimed that grass growing in clearings (especially in clearings made by us where *Cynodon* is always planted) and grass roots bind soil more firmly than tree roots. An exponent of the first point of view was Gillman (1943) and of the second Morris (1946). Very little concrete evidence was available, and we decided to make some measurements comparing the rate of scour in the clearings with that in an untouched block of forest.

DESCRIPTION OF THE RIVER

The Kuja River is 20 to 30 yards wide in dry weather, and perhaps twice as wide in normal floods which do not cause it to overflow its banks. In the stretch we were observing, the river is only rarely straight for more than about 100 yards. Normally its course consists of a series of broad semi-circular bends, alternately to the right and to the left. All these bends conform closely to a pattern which is shown in Fig. 1. For a short distance at the pitch of each bend the outer bank is of vertical bare earth. This is the place where lateral scour takes place.

In Fig. 1 the top of the erodable vertical bare bank is shown as clothed with forest.

This condition is photographed in Fig. 2. In many cases, however, the erodable vertical bare bank is clothed on top not with forest but with grass. This is because the reverine forest strip is relatively straight-sided, following the general course of the river, and some of the larger bends thrust sideways clear of the forest into the surrounding grassland. Our observations in the forest were confined to bends where the top of the vertical bank carried trees, since the others appeared to be, in effect, in clearings.

Judging from preliminary appearances, it seemed that the clearings had no advantage over the untouched block as regards grass cover, since the bare vertical banks were not grass covered (see Fig. 3) even in clearings 13 years old (one of our clearings was an enlargement of one made by the Medical Department in 1934). But in the untouched forest the banks opposite the bare vertical places were covered with a high dense thicket of *Ficus capreifolia*. The removal of this thicket must, we thought, allow the flood water to get away easier, so lessening scour on the vertical bank opposite, and causing there to be less scour in the clearings than in the forest.

THE OBSERVATIONS

Our clearings had isolated a two-mile block of forest, known as Block VII, with clearings upstream and downstream. We decided to observe eight bends at the upper end of Block VII, to be compared with eight bends as close by as possible in the upper clearing, and eight bends at the lower end of Block VII, to be compared with eight bends as close by as possible in the lower clearing. Actually three bends in the upper end of Block VII and one bend in the lower clearing were not marked because the work was overtaken by floods, and the mark disappeared from one bend in the lower end of Block VII, so that we have observed only 12 bends in Block VII to compare with 15 bends in clearings.

To mark the bends, the mid-point of the bend where scour appeared most likely was selected, and a heavy numbered stake of termite resistant timber was driven into the ground exactly 10 feet from the edge. After

seven months, and again after 18 months, the distance of the stake from the edge was measured. On some bends it was difficult to decide the correct point to put the stake. In such cases two, or even three, stakes were put in, spread over 10 to 60 yards. The mean loss from the stakes of any one bend was taken as the loss for that bend.

The stakes were put in in March, 1947. Exceptionally heavy floods occurred in April–May, 1947, and after the floods the distances of the stakes from the edge of the banks were measured. Normal floods occurred again in April–May, 1948, and the stake distances were measured again in September, 1948.

One bend (No. 1 in the upper isolation clearing) scoured so much that the stake

disappeared and the loss was recorded as 10 ft.+. The remainder lost less than 10 ft.

The details of measurements are given in Tables I–IV. The results may be summarized as follows:—

	Mean Loss per Bend in Feet	
	October, 1947	September, 1948
CLEARINGS:		
Upper Clearing (8 bends)	2.27+	2.5+
Lower Clearing (7 bends)	0.95	1.64
BLOCK VII:		
Upper End (5 bends) ..	1.30	2.95
Lower End (7 bends) ..	1.32	2.29

There was slightly more scour in the block of forest than in the clearings, but the difference is not statistically significant.

TABLE I
SCOUR IN UPPER ISOLATION CLEARING. ALL STAKES PUT TEN FEET FROM BANK IN MARCH, 1947

BEND No.	DISTANCE STAKE FROM BANK		LOSS AS AT		MEAN LOSS PER BEND	
	October, 1947	September, 1948	October, 1947	September, 1948	October, 1947	September, 1948
1	0	0	10.0+	10.0+	10.0+	10.0+
2A	8.5	8.0	1.5	2.0	2.75	3.25
B	6.0	5.5	4.0	4.5	—	—
5A	8.0	8.0	2.0	2.0	2.17	2.17
B	7.5	7.5	2.5	2.5	—	—
C	8.0	8.0	2.0	2.0	—	—
9A	10.0	10.0	0	0	0	0
B	10.0	10.0	0	0	—	—
10A	10.0	10.0	0	0	0	0
B	10.0	10.0	0	0	—	—
11A	8.5	8.5	1.5	1.5	1.75	2.0
B	8.0	7.5	2.0	2.5	—	—
12A	8.5	8.5	1.5	1.5	1.5	2.58
B	10.0	7.0	0	3.0	—	—
C	7.0	6.75	3.0	3.25	—	—
13A	10.0	10.0	0	0	0	0
B	10.0	10.0	0	0	—	—
Totals ..	..	..	..	..	18.17+	20.0+
Means (8) ..	..	..	..	..	2.27+	2.5+

TABLE II
SCOUR IN LOWER ISOLATION CLEARING. ALL STAKES PUT TEN FEET FROM BANK IN MARCH, 1947

BEND No.	DISTANCE STAKE FROM BANK		LOSS AS AT		MEAN LOSS PER BEND	
	October, 1947	September, 1948	October, 1947	September, 1948	October, 1947	September, 1948
17A	10.0	10.0	0	0	0.63	2.5
B	8.75	5.0	1.25	5.0	—	—
19	10.0	10.0	0	0	0	0
20	10.0	10.0	0	0	0	0
25	7.0	7.0	3.0	3.0	3.0	3.0
26	8.0	7.0	2.0	3.0	2.0	3.0
27	9.0	8.0	1.0	2.0	1.0	2.0
28	10.0	9.0	0	1.0	0	1.0
Totals ..	..	..	..	..	6.63	11.5
Means (7) ..	..	..	..	..	0.95	1.64

TABLE III

SCOUR IN UPPER END OF BLOCK VII. ALL STAKES PUT TEN FEET FROM BANK IN MARCH, 1947

BEND NO.	DISTANCE STAKE FROM BANK		LOSS AS AT		MEAN LOSS PER BEND	
	October, 1947	September, 1948	October, 1947	September, 1948	October, 1947	September, 1948
3A	6.25	5.5	3.75	4.5	2.38	3.0
B	9.0	8.5	1.0	1.5	—	—
4A	9.5	8.0	0.5	2.0	0.25	4.5
B	10.0	3.0	0	7.0	—	—
5A	8.25	8.0	1.75	2.0	1.5	2.5
B	8.75	7.0	1.25	3.0	—	—
7A	10.0	10.0	0	0	0.63	0.75
B	8.75	8.5	1.25	1.5	—	—
8A	7.0	5.0	3.0	5.0	1.75	4.0
B	9.5	7.0	0.5	3.0	—	—
Totals ..	—	—	—	—	6.51	14.75
Means (5) ..	—	—	—	—	1.30	2.95

TABLE IV

SCOUR IN LOWER END OF BLOCK VII. ALL STAKES PUT TEN FEET FROM BANK IN MARCH, 1947

BEND NO.	DISTANCE STAKE FROM BANK		LOSS AS AT	
	October, 1947	September, 1948	October, 1947	September, 1948
21	8.75	8.0	1.25	2.0
22	9.0	6.5	1.0	3.5
23	8.5	8.0	1.5	2.0
24	8.0	7.0	2.0	3.0
29	8.5	8.5	1.5	1.5
30	8.0	7.0	2.0	3.0
32	10.0	9.0	0	1.0
Totals ..	—	—	9.25	16.0
Means (7) ..	—	—	1.32	1.29

CONCLUSIONS

It seems clear that removal of the riverine forest has no very startling effect on the rate of lateral scour. This is as would be expected, once it is realized that the scour only occurs in places where the bank is bare and vertical, and that these places are scarcely changed by the removal of the forest.

The observations are being continued.

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THE USE OF BENZENE HEXACHLORIDE AS A DISPERSABLE POWDER (GAMATOX 2) IN CATTLE-DIPPING TANKS

By S. G. Wilson, Senior Veterinary Research Officer, Entebbe, and S. B. Nondo, Assistant Veterinary Officer, Ngogwe, Uganda

(Received for publication on 20th May, 1949)

A preliminary account of the measures in progress to popularize mixed farming and improve stock-keeping methods at Ngogwe in Kyagwe County, Buganda, has already been given (Kerkham *et al.*, 1947). No scheme of cattle improvement would be complete which did not include improved methods of disease control, and as tick-borne diseases constitute a major problem in this area the Veterinary Department constructed two dipping tanks at Ngogwe in 1946. These two tanks were opened in May, 1947, one at Kunyu and one at Bukaya and they have been under our care since that date. They have been in almost constant voluntary use by the cattle owners belonging to the Livestock Association, Ngogwe, and a note on the results achieved may be of interest.

MATERIAL AND METHODS

The tickicidal preparation used in each tank was "Gamatox 2", a proprietary dispersable powder containing 50 per cent of benzene hexachloride (B.H.C.). The dilution rate was 10 lb. of "Gamatox 2" to 1,000 gallons of water (1 in 2,000 of B.H.C.), so that the dipping wash on chemical analysis should contain 50 mgm. of B.H.C. per 100 ml. fluid. At regular intervals the level of the tank was maintained by adding 1,000 gallons of water and 10 lb. "Gamatox 2" (5 lb. B.H.C.).

Rhipicephalus appendiculatus is by far the most prevalent tick species in the area. In young animals the great majority of adult ticks of this species attach on the ear, and, as infestations are heavy, ulceration, bleeding, and deformation of the ear pinna, with pus formation in the external meatus of the middle ear and swelling of the parotid glands, are common sequelæ. In older animals the numbers of ticks attaching were greater than in young calves, and not only were the ears heavily infested but many *R. appendiculatus* adults were found attaching on the hind-quarters of the udders and round the anus and vulva.

Amblyomma variegatum is also common in this area, the adults and nymphs attaching on

the udder, scrotum and dewlap. *Rhipicephalus evertsi* is found in only small numbers. During 1947 the method of assessing the toxic effects of B.H.C. on these tick species was by the system of tick-counts previously described (Wilson, 1948). Adult *R. appendiculatus* ticks were counted on the ears of five animals immediately before dipping, and again on the first, third and fifth days after dipping. The difference in the number of ticks counted immediately before dipping and those found alive 24 hours later was taken as representing approximately the number of ticks killed by dipping, and, calculated as a percentage of the first count, was regarded as expressing the tick-killing power of the dip. Since deaths in calves were seldom notified, and very few spleen smears were collected, the effect of dipping on the incidence of East Coast Fever could not be estimated.

RESULTS DURING 1947

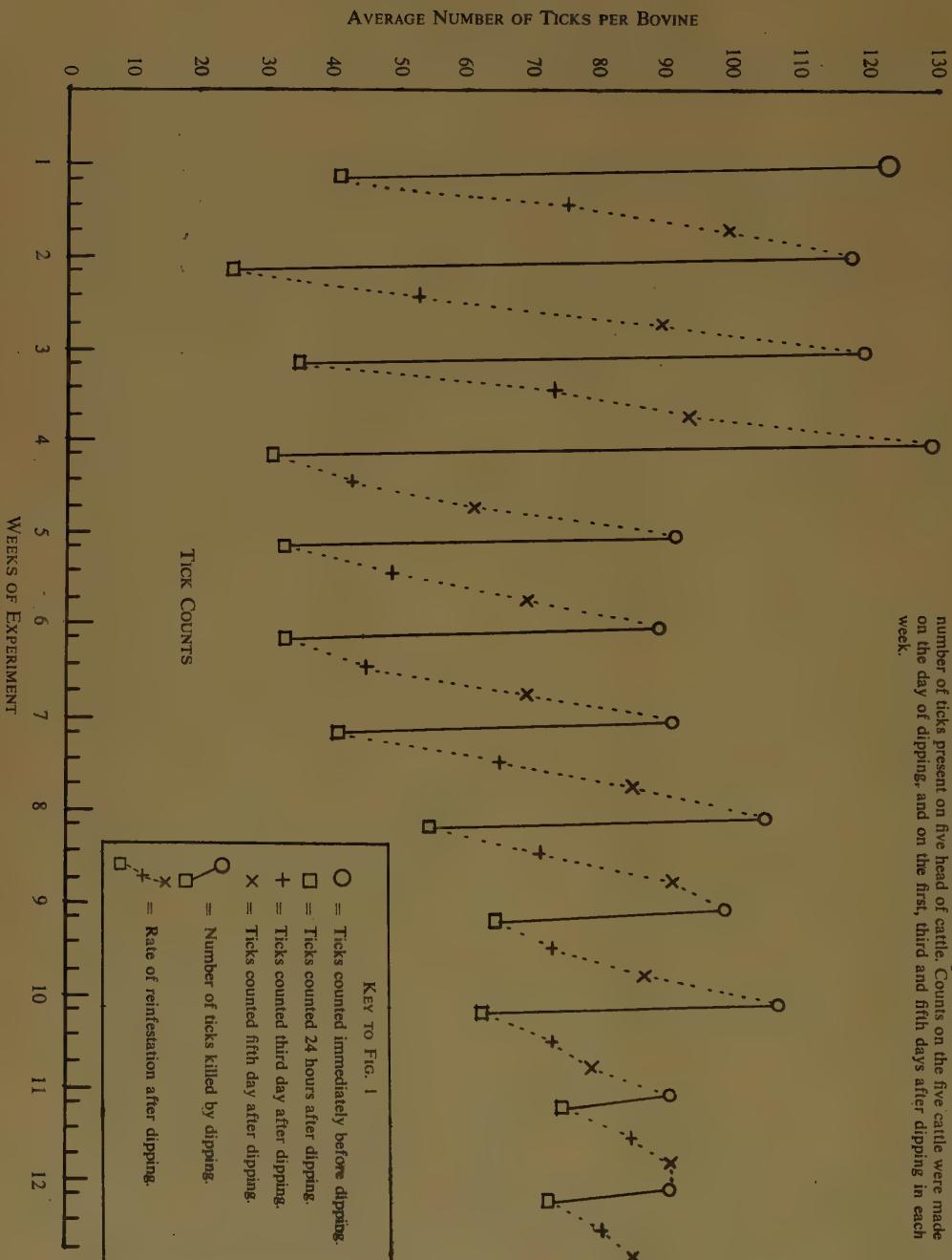
Both the tanks at Ngogwe were opened during the first week in May, 1947, and excellent results were obtained during that month. In most cases, 85 per cent or more of the adult *R. appendiculatus* attached on the day of dipping were dead 24 hours later, cattle remained relatively free of ticks for about three days after dipping, and the raw ulcerated areas on the ears healed rapidly. The only ticks to escape the lethal effects of the B.H.C. were three-quarters or fully engorged females, and these lived to lay viable eggs. However, as engorged females represented only a small proportion of the total ticks attached, the advantages of dipping were very evident to the African cattle owners, who were delighted with the results.

The high tick-kills were maintained during June, but in July the mortality was only 60 per cent and it fell during August to as low as 20 per cent. Cattle owners now complained, and the number of cattle brought for dipping decreased. An attempt was then made to improve the tickicidal properties of the dip, and in both tanks during September to November, 1947, dip was added at double strength, six

Fig. I

LEGEND

FIG. I.—Chart showing fluctuations in tick-population due to weekly dipping in Gamatox 2. The average number of ticks per bovine was calculated from the number of ticks present on five head of cattle. Counts on the five cattle were made on the day of dipping, and on the first, third and fifth days after dipping in each week.



tins of "Gamatox 2" (30 lb. B.H.C.) being added during this time while only 3,000 gallons of water were added to maintain the levels in the tanks. The percentage of ticks killed rose to 67 per cent in September and 62 per cent in October, but there was a marked decrease during November. Cattle owners were so dissatisfied with these results at this time that dipping operations were stopped and the tanks were cleaned in December.

Dipping wash collected in November was tested biologically in the laboratory by Laws' method (Laws, 1948) and gave good kills using adult non-engorged ticks. Chemical analysis of the sludge showed a concentration of 0.14 per cent B.H.C. or approximately three times the original concentration of the wash. It was therefore assumed that the B.H.C. had lost its wetting power due to changes in the dirty dipping fluid.

RESULTS IN 1948

In March, 1948, the tank at Kunyu was refilled with "Gamatox 2" at the same strength as in 1947, i.e. one part B.H.C. to 2,000 parts water. The efficiency of the dip was assessed on the results of tick counts, chemical analysis of the wash at 14-day intervals, and by reports from African cattle owners. The data collected from this tank over a nine-month period is given in Table I. As in 1947, tick-kills during the early weeks were satisfactory, but there was a noticeable decline from the seventh week onwards and kills on the twelfth week were most unsatisfactory. Chemical analysis showed that the B.H.C. content remained high until the twenty-first week, but from the twenty-third until the fortieth week, analysis was disappointingly low. The addition of an extra 10 lb. of "Gamatox 2" on the thirty-first, and again on the thirty-ninth week, gave little improvement. On the thirty-first week the tick-kill was moderately good, but again there was a steady decline until a further quantity of B.H.C. was added on the thirty-ninth week. Cattle owners were, however, dissatisfied with the results and there was a definite decrease in the number of cattle dipped during the thirty-seventh to forty-third week. Dipping was therefore stopped on the 21st December, the tank cleaned, and analysis of two samples of the sludge showed a B.H.C. content of 0.68 and 0.75 per cent, a figure considerably in excess of that found in December, 1947.

The effect of dipping during the first 12 weeks (March–May, 1948), as assessed by

counts on five cattle, are shown in Fig. 1. Although the number of ticks killed was high, there appeared to be little reduction of the tick population in the area until after the fifth dipping. There was a marked drop in the counts on the fifth week, and this reduction was more or less maintained until the twelfth week when counting was discontinued. A decrease in the number of ticks killed is noticeable from the seventh week onwards (Table I). During the thirty-second to forty-third weeks, counts showed that the tick population had risen considerably and as many as 1,500 ticks on five animals were frequently found. The rapid increase in ticks found alive on the third and fifth days shows the absence of residual toxicity.

DISCUSSION

The results of trials over a period of two years show that "Gamatox 2" is not an ideal preparation for use in dipping tanks.

Two problems arose in the management of the Kunyu tank during nine months in 1948 (Table I). At the eighth week, after 6,596 cattle had been dipped, tick-kills fell below 50 per cent. They were especially low during the eleventh and twelfth weeks, although the B.H.C. content as shown by chemical analysis was above normal strength. This could be explained by a masking of the B.H.C. particles occurring in a dirty dipping wash or by a change in the isomeric composition of the B.H.C., causing a loss of the active gamma isomer.

The sudden drop in the B.H.C. content from the twenty-third week onwards would appear to be due to actual destruction or volatilization of the B.H.C. or the B.H.C. was being deposited in the intractable sludge.

The results of these experiments could be serious if Uganda had already embarked on a large-scale programme of tick-control by dipping, since arsenical preparations are dangerous unless strict control in their use can be exercised, and D.D.T. preparations have proved expensive. Limited trials of emulsion preparations of B.H.C. have revealed the difficulties of maintaining the strength of the dipping wash owing to the selective removal of the B.H.C. particles on the coats of the cattle. Fortunately a policy of tick-control by cattle spraying rather than dipping is not only more suitable to our present needs but will

enable us to use the new insecticides to better advantage.

Our thanks are due to the Cooper Technical Bureau, Berkhamsted, who kindly supplied us in 1947 with the original quantities of "Gamatox 2", to the chemist attached to the Colonial Insecticidal Research Team, Entebbe, for the analysis of the dip samples, and to the Director of Veterinary Services, Kampala, for permission to publish this paper.

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TABLE I
 DATA COLLECTED AT KUNYU TANK, NGOGWE, DURING A PERIOD OF 43 WEEKS FROM 2ND MARCH UNTIL 21ST DECEMBER, 1948

Week of experiment	Water added in gal.	B.H.C. added in lb.*	Cattle dipped	Chemical analysis of wash mgm. 100 ml.	Per cent tick-kill
1	4,000	20	459	42·5	67
2	—	—	869	—	79
3	—	—	1,049	46·7	70
4	—	—	1,011	—	77
5	1,000	5	1,085	55·4	65
6	—	—	1,061	—	64
7	—	—	1,062	76·5	54
8	—	—	1,086	—	48
9	1,000	5	1,059	70·0	28
10	—	—	1,096	—	30
11	—	—	1,072	73·0	17
12	—	—	1,068	—	19
13	1,000	5	994	75·0	—
14	—	—	887	—	—
15	—	—	1,042	78·5	—
16	—	—	1,037	—	—
17	1,000	5	998	67·5	—
18	—	—	1,003	—	—
19	—	—	939	77·0	—
20	—	—	860	—	—
21	1,000	5	868	70·0	—
22	—	—	721	—	—
23	—	—	771	35·0	—
24	—	—	845	—	—
25	1,000	5	770	15·5	—
26	—	—	849	—	—
27	—	—	975	33·0	—
28	—	—	977	—	—
29	—	—	985	19·0	—
30	1,000	5	949	23·5	—
31	Nil	5	917	19·0	—
32	—	—	942	—	51
33	—	—	929	32·5	54
34	1,000	5	867	28·5	43
35	—	—	960	22·0	48
36	—	—	873	—	48
37	—	—	730	—	31
38	—	—	600	10·5	27
39	Nil	5	735	—	72
40	1,000	5	551	27·0	51
41	—	—	716	—	48
42	—	—	556	45·5	59
43	—	—	792	—	51

*One 10-lb. tin of Gamatox 2 represents 5 lb. B.H.C.

THE CONTROL OF WHITE STEM-BORER (*ANTHORES LEUCONOTUS*) IN ARABICA COFFEE

By J. K. Robertson, Department of Agriculture, Tanganyika Territory

(Received for publication on 29th March, 1949)

Coffee growing in the lower-altitude areas in East Africa has for long been seriously hampered by the activities of the White Stem-Borer (*Anthores leuconotus*) and the lack of practicable measures to deal with this pest. Detailed descriptions of the insect and its life history have been given by Knight [1]; control measures have been given by him, by Davies [2], by McDonald, J.H. [3] and McDonald, J. [4]. It is not proposed to elaborate further on the bionomics of the insect except to state certain facts regarding its life history as established during a borer-control campaign in Tanganyika.

LIFE HISTORY

Adult.—In Northern Tanganyika adult borer-beetles are in flight when the weather is both warm and moist, e.g. during and after the short rains (as in Arusha District) or in the period of warm weather at the beginning of the main rains (as in certain areas of Moshi District). It is seldom that beetles are in flight for more than two to three months in any year. Preliminary signs of beetle activity are the gnawing of mature (i.e. brown) bark immediately below the area of green bark in coffee trees.

Egg.—When the female wishes to oviposit she prefers to do so at or near ground level although eggs may be laid almost anywhere in mature wood on the coffee tree. The eggs are laid singly and can be detected by a small depression in the bark covered with a dark-brown shiny substance placed there by the female to keep the egg in place. The eggs are whitish in colour, are oval in shape and are laid with the pointed end uppermost.

Larva.—The larva on hatching tunnels superficially in the soft bark and only when the mandibles are sufficiently strong does it enter the wood of the tree. During this period of superficial tunnelling the larva does the greatest damage of all to the coffee plant and may completely ring-bark the stem before tunnelling into the wood. Larvae can be detected and destroyed at this stage by rubbing the stems with a piece of hessian or sacking and if this work is thoroughly done few

larvae are left to enter the stems. Larvae which enter the hard wood of the stems tunnel upwards, the tunnels being marked externally by strands of frayed wood ("frass") so typical of *Anthores* borings.

Pupa.—Pupae are formed at the upper end of larva tunnels, the pupal chamber being broader than the larval tunnel and sealed off from it by densely packed "frass". The pupal chamber is so situated that the emerging adult has to do a minimum amount of gnawing to liberate itself.

CONTROL

In any given area of coffee *Anthores* are seldom found above a certain height; on Mount Kilimanjaro this is reckoned to be 3,800 ft. to 4,000 ft. above sea level. In the Arusha District *Anthores* are found well above this level, especially on the western, i.e. the drier side of mount Meru.

It is very obvious to anyone conducting an anti-borer campaign that the greatest numbers of borer are found in trees which are in a poor vegetative condition. Also, when such borer-infested trees are uprooted it is often found that a malformed tap-root has been a contributory cause of the poor vegetative condition of the tree. Obviously, the first principle in combating *Anthores* is (a) correct planting and (b) to keep the trees in good vegetative condition. The latter implies prevention of over-cropping by correct field practice.

A campaign for the removal of indigenous wild host trees was undertaken on Kilimanjaro some years ago, but this practice has now been discontinued as being too expensive and unworkable.

Provided the rubbing of coffee stems to detect and destroy young larvae (boring superficially) is thoroughly done, few larvae will be left to enter the stems. When entrance into the stem is shown by the typical "frass", most people advocate removal of the larva by a piece of wire. This method is at the best tedious and costly but its greatest fault is that many larvae are left behind. Trees which are badly attacked in the upper part of the stem, but of which the lower parts are sound, can

be stumped, and a sucker (preferably well established beforehand) allowed to take the place of the damaged stem, but badly infested trees are best removed entirely, since once the portion of the tree at or below ground level has become thoroughly damaged by borer tunnels the tree can never recover its full bearing capacity. Such trees are best uprooted and replaced by young plants, but it will be several years before these young trees are in full bearing.

Control of larvæ by chemical means has seldom been done in the past, presumably because few coffee planters were prepared to risk possible damage to their coffee trees. It is true that no scientifically designed experiments have ever been conducted to find out exactly what effect these chemicals have on coffee trees, and, more important still, what effect, if any, they have on the coffee bean. As far as is known no such experiments have ever been carried out and with the introduction of the newer insecticides it is most important that this should be done. In the past the chemical usually advised was Carbon Bisulphide; this is certainly most effective in killing *Anthores* larvæ and there is no visible sign of any injurious effect on the coffee tree. In war-time, few shipping companies would accept Carbon Bisulphide as cargo on account of its volatility and inflammability, and even with the return of peace most shipping companies still show a considerable reluctance to accept it as cargo. An effective substitute was found in Ethylene Dichloride-Carbon Tetrachloride (E.D.C.T. for short) in the proportion of three parts of Ethylene Dichloride to one part Carbon Tetrachloride by volume. It does not possess the same insecticide effect as Carbon Bisulphide but will give a certain "kill" of *Anthores* larvæ used either pure or diluted with up to twice its volume of petrol. This was the material used in Arusha District in 1947 and which proved very effective. Petrol alone was tried and although it was found to be effective if the borer tunnel was a short one, larvæ at the end of a long tunnel were merely stupefied and recovered later. In practice, a mixture of equal parts E.D.C.T. and petrol was used and proved very successful, again without any visible injurious effects on the coffee tree. Most petrol nowadays contains tetraethyl lead but it is still possible to obtain petrol without this addition—in case there is any doubt whether the tetraethyl lead is injurious. There is no such evidence so far.

The field practice consisted in equipping each man of the "borer gang" with a small bottle of the E.D.C.T.-plus-petrol mixture, together with a supply of cotton wool and a bottle of water. Search for borer-infested trees was done by children. Borer tunnels were cleared of "frass"; a twig with a small amount of cotton wool on the end of it dipped in the E.D.C.T./petrol mixture was pushed as far as possible into the borer tunnel, the protruding end was snapped off and the tunnel sealed with mud made on the spot with the supply of water carried.

The advantages of this method are its effectiveness coupled with the speed and low cost at which it can be carried out. Planters who rightly complained in the past that they had no effective method of ridding coffee trees of *Anthores* larvæ without damaging the coffee tree nowadays have no such excuse. Trials conducted show that Ethylene Dichloride and Carbon Tetrachloride have no adverse effect on plant growth.

With the introduction of the newer insecticides (D.D.T., Gammexane, etc.) queries have naturally been raised as to any possible advantage their use might confer. D.D.T. has been used locally by the Custodian of Enemy Property on ex-enemy estates but this has since been discontinued. Gammexane was not used on borer-tunnels during this campaign, but one method which was tried on a small scale was to apply Gammexane Wettable Powder (D.P. 530) in water to coffee stems at the time of emergence of the adult borer beetles. The owner of the estate reported that there was a marked diminution of borer attack on treated trees but it is too early to judge the effectiveness of this treatment. Tanganyika planters do not have the mealy bug (*Pseudococcus kenyae*) problem common in Kenya in which biological control is so important, but further experimentation is required on this point and this is being carried out.

MULTIPLE STEM COFFEE

In the past it has been contended that the multiple-stem system of growing coffee was unsuitable for the lower-altitude areas on account of the difficulty in removing *Anthores* grubs with a piece of wire from the forks of the multiple stems. While this may have been true in the case of mechanical methods of extraction it does not apply where chemical control is used. Since it is generally conceded

that multiple-stem coffee gives higher yields than coffee on the single-stem method, besides being a more consistent yielder from year to year, there is no need to keep coffee on the single-stem method in the lower-altitude areas on account of the difficulty of dealing with *Anthores*.

USE OF RESISTANT SPECIES OF COFFEE

Certain *Coffea* species (e.g. *C. excelsa*) are more resistant to the attack of *Anthores leuconotus* than is *C. arabica*, yet although it has been shown [5] that grafting is a perfectly feasible method of propagating coffee this method of grafting *Arabica* coffee on to other species has never been developed. The region of the coffee tree below ground level is the region most difficult to keep free of grubs, and once a coffee tree is thoroughly riddled with *Anthores* tunnels just below ground level the tree can never again recover its former yielding capacity, and there is only one remedy—uproot and replant. In a grafted tree the root-stock and the stem for a few inches above ground level would be of a resistant species and borer-damage at or below ground level would be either eliminated or very considerably reduced. The above ground (*Arabica*) part of the grafted tree would still be liable to borer attack but this can easily be dealt with by the chemical methods described above. *C. excelsa* is also more drought-resistant than is *C. arabica*—an important factor in the lower-altitude coffee areas. A common sequence in such areas is—failure of the short rains in November/December—outbreak of *Thrips* in January/February—attack by *Anthores* on the weakened trees. The latter phase is consistent with the statement made above that the greatest number of *Anthores* larvae are found

in trees which are in a poor vegetative condition.

SUMMARY

(1) An account is given of a campaign conducted against White Stem-Borer (*Anthores leuconotus*) in coffee.

(2) Mechanical extraction of *Anthores* grubs on a large scale is not practicable; at the best it is extremely tedious but its greatest defect is that many borer grubs may be left behind. Control by chemical means is both effective and practicable.

(3) The chemical used during this campaign was Ethylene Dichloride Carbon Tetrachloride either alone or diluted with an equal volume of petrol.

(4) Chemical control is particularly suitable for control of *Anthores* in multiple-stem coffee.

(5) Certain species of *Coffea* notably *C. excelsa* show considerable resistance to *Anthores* and the possibility of grafting *C. arabica* on to the resistant *C. excelsa* is mentioned.

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OBSERVATIONS ON PALATABILITY OF SOME LEGUMINOUS PLANTS OF KENYA

By A. V. Bogdan, Pasture Research Officer, Department of Agriculture, Kenya

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Little is known about the palatability of East African indigenous legumes. In order to obtain more information on this subject, samples of thirteen leguminous plants have been collected and fed to cattle and sheep. Some of the species tried (particularly *Alysicarpus glumaceus* DC. (Fig. 1) and *Indigofera retroflexa* Baill. (Fig. 2) are promising for introduction into cultivation, others are less promising or not at all in this respect, but none the less it is important to know their grazing value in natural pastures.

All samples were collected in the vicinity of Nairobi, in quantity sufficient for feeding during a few hours two young steers and two sheep used for the experiment. The actual green weight of the samples varied between six and eighteen pounds. The animals were kept in stables and fed with lucerne hay and green Kikuyu Grass. They were last fed prior to the experiment early in the morning while the legume under test was given to them at about 12 hours or 13 hours. Thus the animals were reasonably hungry (but not too hungry) when receiving the legume. The observations were carried out at the Veterinary Research Laboratories, Kabete, from 25th May to 10th June, 1948.

The following seven species (out of thirteen under trial) were found to be palatable both for cattle and sheep:

Alysicarpus glumaceus DC.,
Indigofera tettensis Klotz,
Glycine javanica L.,
Rhynchosia elegans Rich.
Indigofera endecaphylla Jacq.,
Indigofera retroflexa Baill.,
Vigna fragrans Bak. f.

Two species, namely *Indigofera arrecta* Hochst. and *Crotalaria incana* L.* were found to be unpalatable for cattle and sheep alike.

Four species were found to be only partially palatable. Of these *Rhynchosia minima* DC. is disliked and sparingly eaten by sheep while cattle will consume it but not very willingly. *Rhynchosia memnonia* DC. is disliked and eaten only to a small extent by both cattle and sheep. *Sphenostylis marginata* E. Mey.? and *Teramnus labialis* Spreng. are of low palatability to sheep but are liked and well-eaten by cattle.

The following table contains the necessary details obtained from the observations.

ACKNOWLEDGMENTS

I wish to express my thanks to the Senior Agricultural Officer (Pasture Research) Mr. D. C. Edwards for his valuable advice and to Mr. H. M. W. Webb for assistance. Facilities for the experiments were very kindly provided by the Veterinary Research Laboratories, Kabete.

* *Crotalaria incana* in Tanganyika is believed to be the cause of a disease in cattle not unlike crotalariosis or "Stiff-sickness". (P. J. G.)

TABLE—OBSERVATIONS ON PALATABILITY OF SOME LEGUMINOUS PLANTS OF KENYA

No.	BOTANICAL NAME	STAGE IN GROWTH (OF THE SAMPLE)	ORIGIN OF THE SAMPLE	DISTRIBUTION IN NAIROBI AREA	SOME FEATURES OF THE PLANT	PALATABILITY TESTS		
						CATTLE (two young steers)		SHEEP (two animals)
given	eaten	left	given	eaten	left	given	eaten	left
1	<i>Alysicarpus glumaceus</i> D.C. (Fig. 1).	Flowers and young pods	Kabete. Grassland on moist soil.	Common in grassland throughout the area except on black cotton soil.	Sub-erect perennial herb with entire leaves. Leaves somewhat bitter. Good seeder. One of the most promising legumes for introduction into cultivation.	<i>Lb.</i> 12	<i>Lb.</i> 12	<i>Lb.</i> 0
2	<i>Crotalaria incana</i> L.	Flowers.	Kabete. Grown in experimental plots.	Occurs as a weed in arable land. Also in resting land, alongside roads, etc.	Annual tall herb with hairy stems and leaves.	12	12	0
3	<i>Glycine javanica</i> L.	Flowers.	Nairobi. Cultivated at Scott Agricultural Laboratories. Nairobi. Alongside road.	Common in grassland and mixed grass-bush vegetation.	Perennial trailing herb (although sometimes with woody stems). Bush three to six feet high with rich foliage.	12	12	4
4	<i>Indigofera arrecta</i> Hochst.	Just before flowering.	Nairobi. Bare area near City Park.	Common on eroded slopes, in grass-bush land, at roadsides, etc.	Spreading or sub-erect perennial herb with hard, somewhat crisp leaflets.	12	12	5
5	<i>Indigofera endecaphylla</i> Jacq.	Flowers and young pods.	Nairobi. Former grassland (cultivated one year and then abandoned).	Very common in grassland and also in eroded and bare places.	Spreading herbaceous or sub-erect plant with very long spreading or sub-erect branches. Good seeder.	8	8	1
6	<i>Indigofera retroflexa</i> Baill. (Fig. 2).	Flowers and young pods.	Nairobi. In grass-land.	Not frequent. Sometimes forms colonies in abandoned cultivation, in bare places, etc.	One of the promising legumes for introduction into cultivation.	11	11	2
7	<i>Indigofera tettensis</i> Klotz.	Flowers and young pods.	Nairobi. In grass-land.	Frequent in grassland (usually moist) throughout the area.	Spreading or sub-erect perennial herb. Advanced pods are very hard and evenspiny; therefore the plant can hardly be palatable at a later stage.	9	8½	4
8	<i>Rhynchosia elegans</i> Rich.	Flowers.	Grass-bush slope to Mbagathi River.	Common in grass-bush vegetation on slopes with rocky, well-drained soil.	Climbing perennial herb with soft, slightly viscous leaves. Bad seeder.	4	4	0
9	<i>Rhynchosia membranaria</i> D.C.	Flowers.	Nairobi. Grassland with scattered bush. Soil red.	Common throughout the area in grassland and among bushes on red soil.	Climbing or spreading perennial herb with thick stems. Leaves and stems densely minutely hairy. Has a distinct scent, not unpleasant but apparently disliked by animals.	7	2½	2

OBSERVATION ON PALATABILITY OF SOME LEGUMINOUS PLANTS OF KENYA.—(Contd.)

No.	BOTANICAL NAME	STAGE IN GROWTH (OF THE SAMPLE)	ORIGIN OF THE SAMPLE	DISTRIBUTION IN NAIROBI AREA	SOME FEATURES OF THE PLANT	PALATABILITY TESTS					
						CATTLE (two young steers)			SHREEP (two animals)		
						given	eaten	left	given	eaten	left
10	<i>Rhynchosia minima</i> D.C.	Flowers.	Nairobi; Moist grassland.	Common in grassland, usually on black cotton soil.	Low spreading (or sometimes climbing) perennial herb with small leaflets and thin stems. The scent (same as No. 9) present but very slight.	Lb. 9	Lb. 8½	Lb. ½	Lb. 3	Lb. 1½	Lb. ½
11	<i>Sphenostylis marginata</i> E. Mey.	Flowers.	Slopes to Mbagathi River.	Rare in the area but rather abundant on slopes and in plains with black cotton soil in localized area near Mbagathi River.	Sub-erect perennial herb up to one foot high with large somewhat fleshy leaflets. It dries very slowly when cut.	10	10	0	4	1	3
12	<i>Teramnus labialis</i> Sprng.	Flowers and young pods.	Kabete. Moist grass land.	Occurs in moist grass land near streams.	Climbing perennial herb with very fine stems. Leaves not shed when dry.	6	6	0	2	½	½
13	<i>Vigna fragrans</i> Bak. f.	Flowers.	Slopes and plains near Mbagathi River.	Frequent in Mbagathi and Ngong area, usually on black cotton soil.	Spreading or climbing perennial herb with lobed, dark-green leaflets.	6	6	0	2	2	0

OBSERVATIONS ON PALATABILITY OF SOME LEGUMINOUS PLANTS OF KENYA



FIG. 1—*Alysicarpus glumaceus* DC.
A: flower; B: pod.

FIG. 2—*Indigofera retroflexa* Baill.
A: flower.

THE SCHOOL OF AGRICULTURE, MAKERERE COLLEGE, UGANDA

The Agricultural Course at Makerere College was first started in 1925. It then consisted of three years' study, the first two years being devoted to general science and the third to agriculture. This agricultural training was mainly undertaken at the Government Agricultural Laboratories, Kampala (now the Medical Laboratories), and on the Agricultural Plantation, which at that time adjoined the building. Much of the instruction was given by officers of the scientific division of the Agricultural Department, and the Plantation was made use of for practical training and field demonstrations.

In 1933 it was decided to lengthen the course from three to five years by the addition of two further years of agricultural training. The syllabus was enlarged with the object of raising the general standard, and a year's practical training was included, to be given during the fourth year of instruction at the Government Farm, Serere, in the Eastern Province.

In 1944 a further change was made by allocating the first term of the fifth year to additional practical training to be undertaken at the Government Farm, Bukalasa, in Buganda. In this way the students were enabled to come into contact with a system of agriculture different from that which they had seen during the previous year at Serere, and at the same time the course became more evenly balanced as between theory and practice.

Another adjustment was made in 1948 when the third and fourth years were interchanged, which meant that students coming up from Higher Science at the College proceeded direct to their practical work at Serere.

An outline of the course as conducted today is given below.

First and second years.—Higher Science at the College (Physics, Chemistry, Biology).

Third year.—Taken at the Government Farm, Serere.

Fourth year.—The following subjects are given at the College:—Agricultural Chemistry, Entomology, Veterinary Science, Crop Botany and Surveying.

Fifth year (first term).—Taken at the Government Farm, Bukalasa.

Second and third terms.—The students are in residence at the College, but a good deal of their time is spent at the Government Agricultural Laboratories, Kawanda (9 miles distant),

where tuition is given by officers of the scientific division of the department. The subjects taken include Agricultural Chemistry, Plant Pathology, Forestry, Entomology, Animal Husbandry, Nutrition and Experimental Method and Plant Breeding.

It will be seen, therefore, that out of the total of nine College terms which comprise the three years of agricultural specialization, four are spent by the students in the field.

The course is conducted by the Board of Studies in Agriculture, first instituted in 1945, which is responsible for its actions to the College Academic Board.

During the year at Serere visits to other centres in the Eastern Province, and to parts of the Northern and Western Provinces are arranged for the students, and whilst in residence at the College a number of day excursions are undertaken to nearby places of agricultural interest.

At first, students who had passed their final examinations were given a certificate of proficiency in Agriculture, but since 1940, when the Makerere College Council was founded, this certificate was replaced by the Diploma in Agriculture (E.A.).

The majority of students who have taken the agricultural course since its inception have come from Uganda, and of this majority the Buganda have been the most numerous. In recent years, however, students from other East African territories have come forward, though their numbers have not been large.

The following tables show the numbers of students who have completed the course over the period 1940-1948, and of those who are engaged in taking the course during 1949.

NUMBER OF STUDENTS COMPLETING THE AGRICULTURAL COURSE, 1940-1948

YEAR	TERRITORY				TOTAL
	Uganda	Kenya	Tan-ganyika	Zan-zibar	
1940	3	—	—	—	3
1941	4	1	—	2	7
1942	7	3	1	—	11
1943	1	1	—	—	2
1944	1	—	4	1	6
1945	3	—	—	1	4
1946	3	—	—	—	3
1947	—	1	1*	—	2
1948	1	—	—	—	1
TOTAL	23	6	6	4	39

*Completed the course, but failed in final examinations

NUMBER OF STUDENTS TAKING THE AGRICULTURAL COURSE, 1949

Year	TERRITORY				Total
	Uganda	Kenya	Tan-ganyika	Zan-zibar	
Third	5	—	—	—	5
Fourth	3	—	—	—	3
Fifth	5	—	2	1	8
TOTAL	13	—	2	1	16

Nearly all successful students have sought and obtained, at any rate to begin with, employment with the various East African Agricultural Departments. There is still a keen demand from these sources, and with the increasing expansion of research institutions and commercial agricultural undertakings in East Africa it seems likely that the range of employment for men with agricultural qualifications will extend.

R. W. STUCKEY.

VEGETABLE COOKERY AT HIGH ALTITUDES

Experiments carried out under controlled conditions are reported from which it is concluded that the chief variations in cooking time as between high and low altitudes occurred in the boiling process. Thus green cabbage, potatoes, parsnips, swede turnips, squash, sweet potatoes, and turnips required 20 to 25 per cent more time for boiling at 7,200 ft. than at 600 ft., equivalent to a mean increase of about 4 per cent in time for each 1,000 ft. rise in elevation. Beet, cauliflower, and onions required 55 to 66 per cent more time, or 9 to 11 per cent increase for every 1,000 ft. rise. Vegetables steamed in pressure cooker at high altitudes (7,200 ft.) cook in the same period of time as at low altitudes (600 ft.), but they require 3 lb. more pressure than normally used.

—Thiessen, E. J., *Repr. Bull.*, Wyoming Agric. Exp. Stat., 180, 1947.

POULTRY

OXYGEN TANK BOOSTS HIGH ALTITUDE HATCHES

Hatcherymen in the mountain States have known for some time that something was wrong with the hatching process at high altitudes. There have been several attempts to find the reason, but it was not until the spring of 1947 that the poultry specialist at the Wyoming Experimental Station was able to place the blame on oxygen starvation. At 7,000-ft. elevations oxygen does not penetrate the egg shell in sufficient quantities, and the chick embryos smother during the incubation period. In an experiment last spring it was demonstrated that adding enough oxygen to the atmosphere in the incubator to provide an "oxygen pressure" equal to that nearer sea level would increase both chick and turkey hatches. Chick hatches were increased approximately 18 per cent under the conditions of the experiment. Turkey hatches were improved well over 100 per cent. The oxygen was needed throughout the full period of incubation.

FURTHER NOTES ON MVULE (*CHLOROPHORA EXCELSA*)

By James T. Templer, Forest Department, Kenya

(Received for publication on 20th May, 1949)

MVULE IN UGANDA

In Uganda Mvule is being underplanted in clean hoed *Terminalia*, fire climax, savanna woodland, which has a reasonably close canopy. With the Mvule are planted savanna mahoganies, *Khaya* spp., and the nurse species *Gmelina arborea* and *Phyllanthus discoideus*. Within ten years the original savanna species are mostly dead and the original grass species largely eradicated. It would be interesting to hear how the rate of volume increment of the Mvule will compare with that grown under the widely different conditions prevailing on the coast of Kenya.

MVULE ON THE KENYA COAST

On the coastal rain belt of Kenya, where Mvule is being experimented with, that particular type of savanna does not prevail. Instead, grassland, if protected, turns in time into light evergreen forest. Further, there is in Mombasa and elsewhere a large and growing demand for bananas, and it is the intention of Government if possible to increase the local food supply and thus lower the cost of living.

For this reason a 60-acre experimental plantation was formed in 1948 on level grassland on the Shimba Plateau (1,200 feet) about 20 miles south of Mombasa. Here a two-acre pilot plot had been established the year before. This showed, and still shows, every sign of good health.

In the 60-acre area the Mvule were planted as two-year stocks at 40 ft. by 40 ft. with banana suckers interplanted at 10 ft. by 10 ft. I consider that this was probably a mistake, as the espacements will soon not allow a tractor and cultivator to pass between the banana clumps. We should, I think, have planted the bananas at 12 ft. by 12 ft. and the Mvule at 48 ft. by 36 ft., thereby practically maintaining the number of trees per acre, but allowing more room for the machinery.

Owing to careful planting, establishment of both Mvule and banana suckers was nearly 100 per cent, and both are growing satisfactorily, particularly the Mvule, which have already put on sizeable crowns.

The aim here is to grow both Mvule and bananas together for as long as the latter can stand the increasing shade and root competition of the Mvule. Full Mvule canopy is anticipated in 20 to 30 years, by which time it is hoped that the profits obtained from the sale of the fruit will more than compensate the cost of the clean weeding throughout the rotation. The ultimate replacement of the bananas by an understory of indigenous hardwoods or by some kind of ground cover in order to keep out the grass is also intended, as this would help to reduce maintenance costs and may even yield a small secondary profit. Other forms of secondary crops such as papaws and chillies are also being considered.

It should be emphasized that the work is experimental, and careful costings of both expenditure and of revenue from cash crops are being kept.

GROWTH OF MVULE

On the coast of Kenya Mvule is deciduous, usually shedding its leaves at least twice a year. The most common resting periods appear to be during or towards the end of the wet seasons and extending for a week or two into the succeeding dry seasons. Individuals vary, however, enormously in their times of leaf casting, so that plantations seldom present an even appearance, different trees often being in every stage at any given moment. It is at present presumed that root development occurs most rapidly between the time of complete leaf production and their starting to wither, i.e. during the wet seasons in the majority of cases. It may perhaps even continue into the resting period.

It has been observed that when young Mvule are either freed from shade or planted out as stocks, their first reaction is to produce as large a crown as the reserves of plant food stored in the tissues will allow. Little height growth occurs at this stage, though girth increment is measurable. This is succeeded a few months later by the first resting period characterized by defoliation, when the tree looks quite dead and has often, in fact, been supposed by visitors to be so.

The young leaves make their appearance after seldom more than a week or two of bareness, and within a month or six weeks the tree is in full leaf again. During this second period of leaf output height growth is again secondary to crown formation, but as period succeeds period height growth gradually speeds up. This may be due to the naturally tall habit of the species occasioned by the necessity to produce more and more branches at greater nodal distances.

Thus the rate of height increment appears to be directly related to the extent of crown formation, and it is now apparent that rapid height growth under the open conditions outlined above cannot be expected for some years after the removal of shade or of planting out. Nevertheless, as witness the tree at Sokoke (see Templer, 1948) and other Mvule planted elsewhere, height growth soon becomes rapid in keeping with the crown size.

After a time the lowest branches cease to develop as rapidly as those higher up become overshadowed, die, and fall off of their own accord. Here pruning might be of value in

order to further the production of clear timber as soon as possible, but care should be taken only to prune branches which show signs of being overshadowed and which can no longer be of much value to the tree, as otherwise the vitality of the tree might be adversely affected. On the coast of Kenya eight to ten years should probably elapse between the time of planting and the time of first pruning, but it is too early as yet to lay down any hard and fast rules.

As stated above, canopy should form in 20 to 30 years at the espacement given. Anything like the near approach of canopy formation is almost certain to have an immediate effect upon height growth and also upon lower branch suppression, since this species appears to be highly intolerant of side shade. It is possible, therefore, that actual pruning operations need not continue after the plantation reaches about 20 years of age.

* REFERENCE

- Templer, J. T. (1948).—Notes on Mvule, *E.A. Agric. J.*, Vol. 13, p. 210

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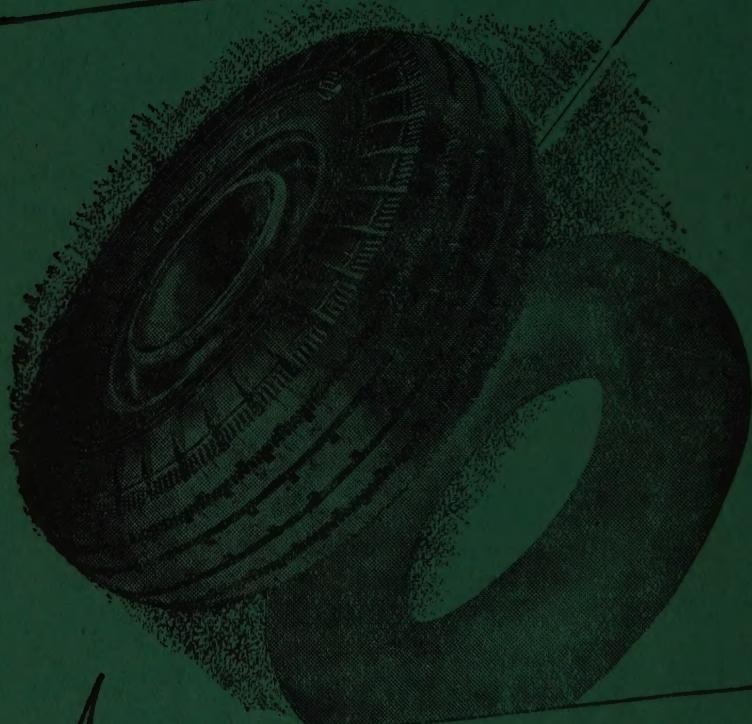
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